SECTION TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 41 00.00 80

CONTRACTOR SAFETY AND HEALTH PROGRAM

-- End of Section Table of Contents --

SECTION 01 41 00.00 80

CONTRACTOR SAFETY AND HEALTH PROGRAM

PART 1 GENERAL

1.1 JSC SAFETY INFORMATION

1.1.1 Safety and Health Information

1.1.1.1 Commitment to Safety and Health

The success of this center starts with an unwavering commitment to safety. The culture of this institution is one of safe accomplishment of our missions, including construction projects.

Mission success starts with safety. A commitment to safety permeates everything we do. We are committed to protecting the safety and health of the general public, astronauts, the workforce, and our high-value assets.

No activities are important enough to compromise the safety and health of any person. If you suspect something isn't quite right, trust your instincts and your experience, and do something to correct the situation. If something about this project, or any task, is unclear, ask for clarification.

JSC is an OSHA Voluntary Protection Program (VPP) Star site. This means that our safety and health program exceeds the minimum OSHA requirements; that we continue to improve our program; that we want you to join with us on making this site a safe place to work. Because of this what was acceptable in other places may not be acceptable here.

The JSC's safety and health policy is that:

> All mishaps can be prevented and everyone must remove or control hazards at work. Management will maintain a safe workplace and ensures employees are trained to work safely. Employees are expected to work safely and watch out for others. Working safely will result in the best possible performance.

1.1.1.2 Safety and Health Culture

Safety and Health are of paramount concern. We assure a commitment by employing systems and processes that ensure the safety and health of the public, the employees, and assets. We ensure safety in all aspects of personal endeavors and we are committed to ensuring the safety of others. We take ownership for safety. We know every incident is preventable.

All employees should be aware of the hazards and the precautions to be taken in performance of work. We not only watch out for ourselves, but we watch out for others around us. Know not only the hazards of your work and how your work affects others, but the hazards of other work around you. Here at JSC we are our "brother's keeper".

Near Miss/Close Call identification by all employees is a positive

mechanism that leads to incident prevention and worker protection.

1.1.1.3 Construction Safety and Health Goals

In this spirit, we expect the Contractor to implement the safety and health provisions of this section so that:

a. Everyone involved in this project goes home as healthy as they arrived.

b. This construction work site is free of recognizable hazards.

c. We have zero reportable incidents in the workplace.

1.2 SUMMARY

The requirements of this Section apply to, and are a component part of, each section of the specifications and requirements of the control package.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 20	Standards for Protection Against Radiation
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1926	Safety and Health Regulations for Construction

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2007; Errata 2008) Flammable and Combustible Liquids Code

JOHNSON SPACE CENTER

JPR 1700.1	Johnson Space Center Safety and Health Handbook

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

The Contractor shall submit the following items in accordance with the paragraph entitled, "Safety and Health Plan Requirements," of this section:

Contractor's General Safety and Health Plan; G

Contract Specific Safety and Health Plan; G

Subcontractor's Safety and Health Plans; G

SD-02 Shop Drawings

The Contractor shall submit the following in accordance with the paragraph entitled, "Pre-Use Planning for Hazardous Operations," of this specification.

Pre-use plans; G
Advanced Notification of Equipment; G

SD-03 Product Data

The Contractor shall submit the following in accordance with the paragraph entitled, "Hazard Communication Program," of this specification

Listing of all Hazardous Material; G
Material Safety Data Sheets; G

SD-06 Test Reports

The Contractor shall submit the following items in accordance with the paragraph entitled, "Safety and Health Activity Reports," of this specification:

Safety and Health Activity reports; G

The Contractor shall submit the following items in accordance with the paragraph entitled, "Exposure Monitoring," of this specification:

Exposure Monitoring; G

SD-07 Certificates

The Contractor shall submit the following items in accordance with the paragraph entitled, "Radiation and Laser Safety," of this specification:

US Nuclear Regulatory Commission Licenses; G

1.5 SAFETY AND HEALTH PROGRAM GENERAL PROVISIONS

The Contractor shall take all reasonable safety and health measures in performing under this contract and shall submit safety and health plans for the Contracting Officer's approval. The Contractor is subject to: (1) all applicable federal, state, and local laws, regulations, ordinances, codes, and orders relating to safety and health in effect on the date of this contract; and (2) shall comply with safety and health standards, specifications, issuances, reporting requirements, and provisions in the current Johnson Space Center Safety and Health Handbook, JPR 1700.1. See paragraph entitled, "Compliance Reference," of this section.

During the performance of work under this Contract, the Contractor shall comply with procedures prescribed for the control and safety of persons visiting the project site. The Contractor is responsible for his personnel and for familiarizing each of his subcontractors with safety and health requirements. The Contractor shall advise the Contracting Officer of any

special safety restrictions established so that Government personnel can be notified of these restrictions.

Contracting Officer may, from time to time, notify the Contractor in writing of any noncompliance with the provisions of this specification and may specify corrective action to be taken. Further, the Contractor shall take or cause to be taken such other safety and health measures, as the Contracting Officer shall direct. The Contractor shall, after receipt of such notice, immediately take corrective action.

If the Contractor fails or refuses to institute prompt corrective action in accordance with the above, the Contracting Officer may invoke the provisions of the clause in the contract entitled "Stop Work," or may invoke whatever other rights are available to the Government under the terms and conditions of this contract or at common law, to remedy such failure or refusal to institute prompt corrective action.

The Contractor agrees that authorized Government representatives of the Contracting Officer shall have access to and the right to examine the sites or areas where work under this contract is being performed to determine the adequacy of the Contractor's safety and health measures under this specification.

The Contractor shall maintain copies of the Contractor's General Safety and Health Plan, the Contract Specific Safety and Health Plan, each Subcontractor's Safety and Health Plans, permits, Material Safety Data Sheets, and other Safety and Health Program documents on-site readily available for review by all employees, subcontractors, the Contracting Officer and the Government's Safety and Health Representatives.

The Contractor shall ensure that each new employee receives safety and health orientation and that all employees are initially and regularly trained in job safety and health. The Contractor's personnel shall have undergone all OSHA required safety and health training applicable to this project. JSC specific safety and health training may be used to supplement required training but is not intended to replace minimum required OSHA training

1.5.1 Meetings

After the Pre-Construction Conference, before start of construction, and prior to acceptance by the Government of the Safety and Health Plans, the Contractor shall meet with the Contracting Officer to discuss the Safety and Health Program. During this meeting, a mutual understanding of the Contractor's Safety and Health Program and how it integrates with the Johnson Space Center Safety and Health requirements shall be developed. Discussions will include the hazard assessment process, procedures, permits, emergencies, and other requirements.

The Contractor shall meet with the Contracting Officer in a preparatory phase meeting prior to each feature of work to discuss safety and health issues for that Feature of work. Discussions will include hazard assessments, procedures, permits, emergencies, and other requirements.

There may be occasions when subsequent conferences/meetings may be called by either party to reconfirm mutual understandings, to discuss changes to the Contractor's Safety and Health Plans, and/or to address deficiencies in the Safety and Health Program or procedures which require corrective action.

Each work crew shall conduct Daily Safety and Health Review meetings. These "Tool Box" type meetings shall be held before the start of each crew's work shift activities or before the start of a new task/activity during a work shift. These meetings shall be led by the work activity/craft supervisor, foreman, or crew chief and shall review/discuss: (a) basic job steps for the task/activity, (b) potential hazards and corrective actions for each job step, (c) precautions, permits, personal protective equipment, barricades, energy isolation, work platforms, and abatements necessary for the activity, and (d) other pertinent topics and issues. Attendance will be recorded. A Daily Safety & Health Review form shall be used to document minutes of this meeting (see suggested form attached at the end of this section). The Contracting Officer shall be notified at least 48 hours in advance of the time and location of each crew's meeting(s).

The Contractor shall prepare the minutes of each meeting described in this section and furnish them to the Contracting Officer to become part of the contract file.

1.5.2 Inspections

The Contractor shall implement, as a minimum, a four phase inspection system for all definable features of work, as follows:

1.5.2.1 Preparatory Inspection

This shall be performed prior to beginning any definable feature of work. It shall include a review of contract requirements (with all personnel responsible for supervision of the work). Review of contract requirements shall include; a check to assure compliance for all specific requirements for the feature of work, a review of the appropriate activity hazard assessment, hazard abatement plans, and a discussion of procedures for controlling the safety of the work including repetitive deficiencies; examination of the work area to ascertain that all preliminary work has been completed. The Contracting Officer shall be notified at least 48 hours in advance of each preparatory inspection and such inspection shall be made a matter of record in the Contractor's safety documentation. Preparatory Inspections will be reconvened when and if changes in the work or crew occur.

1.5.2.2 Initial Inspection

This shall be performed as soon as hazard abatement plan is in place for that particular feature of work. The inspection shall include examination of the physical implementation of safety and health contract requirements; a review of safety and health procedures, a review of compliance with the activity hazard analysis. The Contracting Officer shall be notified at least 24 hours in advance of the inspection and such inspection shall be made a matter of record in the Contractor's safety documentation. Initial inspections will be reconvened when and if changes in the work or crew occur.

1.5.2.3 Follow-up Inspection

These shall be performed daily to assure continuing compliance with contract requirements until completion of the particular feature of work. Such inspection shall be made a matter of record in the Contractor's safety documentation.

1.5.2.4 Weekly Inspections

The Contractors shall inspect the site at least weekly for hazards and failures in following safety, health, and environmental requirements and document any identified hazards in accordance with JPR 1700.1 Chapter 10.1 "Safety and health requirements for designing, constructing, and operating facilities," Chapter 2.4 Hazard Abatement, Chapter 2.5, "Routine Inspections," and Chapter 3.5 "Hazard Correction Tracking".

1.5.3 Safety and Health Activity Reports

These reports shall be on an acceptable form and shall include factual evidence that required safety and health activities have been performed. The original and one (1) copy of these reports shall be furnished to the Government daily within 24 hours after the date(s) covered by the report, except that reports need not be submitted for calendar days on which no work is performed. One (1) report shall be prepared and submitted for every 7 calendar days of no work and on the last day of a no work period. All calendar days shall be accounted for throughout the life of the contract. The first report following a day of no work shall be for that day only. Reports shall be signed and dated by the Safety and Health System Professional or Safety and Health System Specialist. The report shall include copies of reports prepared by all subordinate safety staff personnel. The reports will include, but not limited to the following:

Plans and permits submitted/furnished/approved

MSDS submitted.

Inspections performed with results and references to specification section or OSHA paragraph. The control phase should be identified (Preparatory, Initial, Follow-Up Completion, or Weekly). List all deficiencies noted along with corrective action taken or proposed.

Investigations of reported hazards, mishaps, close calls/near misses, and other safety and health related incidents with action taken to correct and to prevent recurrence.

List instructions given/received

1.5.4 Inspection and Hazard Tracking Records

Contractor shall maintain on-site the records of each inspection performed throughout the life of the contract. Records shall include, but not be limited to, factual evidence that the required inspections or tests have been performed, including type and number of inspections, result of inspections, nature of defects, causes for rejection, proposed remedial action, and corrective action taken.

1.5.4.1 Hazard Tracking System

The Contractor shall have a system for initiating and tracking hazard elimination or control. The system must; (1) track all hazards identified through inspections, investigations, employee reports, surveys, near misses/close calls, etc. to completion and (2) include interim measures to protect employees and the environment from hazard while permanent action is in work.

1.5.4.2 Hazard Tracking Records

The Contractor shall maintain hazard tracking records that tracks the hazards to closure in accordance with JPR 1700.1 Chapter 3.5 "Hazard Correction Tracking". Records shall include at least the following information: Hazard Identified, when and where identified, actions(s) taken to correct the hazards (Abatement Plans), and when corrected.

1.5.4.3 Hazard Abatement Plans

The Contractor shall record hazard correction to closure using abatement plans (also commonly referred to as action plans or corrective action plans) developed to address hazards found during hazard analyses, mishap investigations, close call investigations, inspections, surveys, and other similar activities where hazards are identified and analyzed.

1.5.5 Mishap Investigation and Reporting

The Contractor will report immediately (within 24 hours) by telephone and by NASA Form 1627 (NASA Mishap Report) to the Contracting Officer all mishaps which fall into the categories:

Type A - Mishaps causing occupational injuries and/or illnesses that result in a death, a permanent total disability, or the hospitalization for inpatient care of 3 or more people within 30 workdays of the mishap; or causing damage to equipment or property equal to or greater than $1 million.

Type B - Mishaps causing occupational injuries and/or illnesses that result in permanent partial disability to one or more persons or result in hospitalization for inpatient care of 1-2 people within 30 workdays of the mishap; or causing damage to equipment or property equal to or greater than $250,000, but less than $1 million.

Type C - Mishaps causing a non-fatal occupational injury or illness which results in a lost workday case or a restricted duty case or a transfer to another job; or causing damage to equipment or property equal to $25,000, but less than $250,000.

Type D - Mishaps causing non-fatal OSHA recordable injuries and/or illnesses that do not meet the definition of Type C; or causing property damage less than $25,000, but greater than $1,000.

Instructions for completion of the NASA Form 1627 are printed on the reverse of the form, Blocks 1-22, 27-28, and 33 are required to be filed with the Contracting Officer within 24 hours of the mishap.

The Contractor will investigate all such work related incidents or accidents to persons and property to the extent necessary to positively conclude what cause or causes resulted in said accident or incident. After the Contractor completes an investigation of the mishap and has developed a plan of corrective action, the Contractor will complete the rest of the NASA Form 1627 and submit it to the Contracting Officer or his/her representative and the Occupational Safety Team. If an investigation board is convened or will be convened, the supervisor or Safety Representative of the Contractor will complete the form as best as possible and forwards it to the Contracting Officer or his/her representative and the Occupational Safety Team.

1.5.6 Near Miss Investigation

A Near Miss/Close Call is defined as an unplanned occurrence in which there is no recordable injury, equipment or property damage less than $1,000, no interruption of productive work, but which has the potential for any of the Mishap categories shown in the paragraph entitled, "Mishap Investigation and Reporting" of this section. A Near Miss/Close Call may result from hazards or unsafe acts.

The Contractor will develop a method or process for his/her employees, or subcontractor employees, to anonymously report Near Misses/Close Calls. The process for reporting Near Misses/Close Calls shall be explained to all Contractor and Subcontractor employees.

The Contractor will investigate all such Near Misses/Close Calls to persons and property to the extent necessary to positively conclude what cause or causes resulted in said Near Miss/Close Call. The Contractor will document his/her investigation and develop a plan of corrective action. The corrective action plan shall be entered into the Contractor's Hazard Tracking System. This documentation will remain on the project site for the duration of the project and shall be made available for review by the Contracting Officer.

1.5.7 Form JF288 "Statistical Information"

Contractor will provide a Johnson Space Center Form JF288, Statistical Information - Contractor Safety and Health Program, to the Contracting Officer each month during the contract period and also at the end of the contract.

1.5.8 Clearance of Roadways

The Contractor shall keep clear for traffic at least one-half of any roadway involved in his operations, and any such road clearance shall be adequate for not less than one-way traffic.

1.5.9 Protection From Injurious Dirt and Dust

The contractor shall protect existing structures, machinery and equipment from injurious dirt and dust from the construction operations at all times. Rubbish and flammable material shall be removed at once.

1.5.10 Hydrostatic or Other Special Testing

Where hydrostatic or other special testing above 25 psig is required under the Contract, the Contractor shall submit for approval a complete and detailed testing procedure and shall not undertake any such testing until the procedure has been approved.

1.6 SAFETY AND HEALTH PLAN REQUIREMENTS

1.6.1 Contractor's General Safety and Health Plan

The Contractor shall submit a current, comprehensive, written General Safety and Health Plan describing the Contractor's overall Safety and Health Program. The General Safety and Health Plan shall be submitted and approved prior to work activities being started. The General Safety and Health Plan shall contain the following items at a minimum:

Safety and Health Policy of the corporation/company signed by the firm's CEO, President, Owner, or other senior executive

Purpose and Scope of the Safety and Health Program

Management Leadership Commitment and Employee Involvement in the Safety and Health Program

Responsibilities of participants in the Safety and Health Program

- Managers
- Supervisors
- Employees
- Safety and Health Manager
- Training Coordinator

Process for Hazard Assessment

Process for reporting hazards and Close Calls/Near Misses and mishaps within the company structure

Process for investigating reported hazards, mishaps and close calls/near misses within the company

Processes for hazard identification, prevention, and control as applicable:

- Inspections and Surveys
- Exposure monitoring (chemical, noise, radiation)
- Asbestos Program
- Lead and Heavy Metal Exposures
- Confined Space Entry Program
- Hearing Conservation Program
- Written Hazard Communication Program
- Written Respiratory Protection Program
- Personal Protective Equipment
- Energy Control and Lockout/Tagout
- Welding and Cutting Program
- Fall Protection Program
- Crane Operations and Heavy Lifting
- Material Handling Program

Scaffolding and Ladder Safety

Excavations and Trenches

Concrete and Masonry Program

Motor Vehicle and Heavy Equipment Operation

Demolition

Other construction activities applicable to the firm

Safety and Health Training Requirements

New Employee Orientation

Initial and refresher training all employees must receive

Initial and refresher training specific to on-the-job hazards and activities

Safety and Health Program Requirements for subcontractors

1.6.2 Contract Specific Safety and Health Plan

The Contractor shall submit a comprehensive, written Contract Specific Safety and Health Plan describing how the Contractor's General Safety and Health Program will be tailored to the activities on this contract at Johnson Space Center. The Contract Specific Safety and Health Plan shall be submitted and approved prior to work activities being started. The Contract Specific Safety and Health Plan shall contain the following items at a minimum:

Names of:

The Safety & Health System Specialist (SHSS). Provide a resume listing this individual's education, work experience and training in occupational safety and health topics.

The Safety & Health System Professional (SHSP), if applicable. Provide a resume listing this individual's education, work experience, and training in occupational safety and health topics.

The appropriate "Competent Person" for specific activities. A "Competent Person" must be named for confined space entry, asbestos work, lead abatement, scaffolding, assured grounding, ionizing radiation, rigging equipment, fall protection, excavations, steel erection, and other construction activities as required by OSHA. Provide documentation of each person's competency. These names may be provided at the beginning of each construction feature of work.

Hazard Assessment(s) specific to the construction activities with identified hazard controls and PPE.

The Contractor's Daily Safety and Health Review Form to be used on the project.

Standardized company procedures that incorporate recognized controls

for the protection of personnel and property.

The contractor should include any standardized procedures written for activities to describe how the contractor's employees will perform that activity or use equipment.

Recognized controls include the use of: fixed, rigid and flexible barricades, warnings, limited access signs, personal protective equipment, work practices, shielding, lockout/tagout, and inspections,

Ground Fault Protection Program

Safety and Health Training that employees will receive before beginning work at JSC and a description of how the training will be documented.

Procedures for hazardous material spill/release at JSC.

Emergency procedures in the event of a fire, personnel injury, and property damage at JSC.

Hazard Communication Program to include location where Material Safety Data Sheets will be kept at the job site.

Written Respiratory Protection Program, if applicable.

Frequency and location of Safety and Health meetings.

Compliance, Enforcement, and Disciplinary actions.

Description of methods and procedures to assure compliance with the Safety and Health Plan by employees and subcontractors.

Description of methods and procedures to enforce safety and health requirements with his employees and the subcontractor's employees.

Description of methods and procedures for the discipline of employees (both his and subcontractors') for violations of the safety and health plans.

Description of methods and procedures for award and reward of employees (both his and subcontractors') for outstanding implementation and compliance of the safety and health plans.

Drug Free Workplace Program

Visitor Protection and Control Program

Safety barricades, signs, and signal lights

Safeguard the public and Government personnel, exposed to operations and activities

Include company procedure for defining smoking risk for the various phases of work. Include company procedure for establishing, maintaining, and enforcing smoking only in designated areas.

1.6.3 Subcontractor Safety and Health Plans

The Contractor shall submit detailed, written Subcontractor Safety and Health Plans as described below. Each subcontractor's plan shall be specific to the activities at Johnson Space Center. The Subcontractor Safety and Health Plans shall be submitted and approved by the Contracting Officer prior to subcontractor work activities being started. The requirements for Subcontractor Safety and Health Plans are:

1. The Subcontractor's Safety and Health Plan shall be a combination of all applicable topics as described in the general and contract-specific plans from paragraphs entitled, "Contractor's General Safety and Health Plan," and "Contract Specific Safety and Health Plan," of this section.

2. Except as listed in the following paragraphs 3 through 8 subcontractors may elect to participate in and be covered by the Prime contractor's Safety and Health Program.

   A senior executive of the subcontractor's firm must sign a statement that they will participate in the prime contractor's program. A copy of this document must be submitted with the prime Contractor's Contract Specific Safety and Health Plan

   The prime contractor will then be responsible for: the safety and health of the subcontractor's employees, providing and documenting all safety and health training for the subcontractor's employees, ensuring compliance with all work practices and hazard assessments/analyses, obtaining permits for all hazardous work performed by the subcontractor, and other safety and health issues affecting the subcontractor's employees on this contract.

3. The Subcontractor will provide:

   Independently documented Safety Experience Modifier Rate (EMR) used to calculate Workmen's Compensation Insurance. The subcontractor must provide the current EMR and the previous two years EMRs.

   Certified evidence of the OSHA Total Recordable Incident Rate (TRIR) with NAICS Code for the current Recordable Incident Rate (RIR) and the previous three full year's RIRs.

   Certified evidence of the OSHA Days away from work, days of restricted work activity or job transfer (DART) rate with NAICS Code for the current DART rate and the previous three full year's DART rates.

   Information on all OSHA citations issued to the firm over the past three years. Additionally, provide information on how each citation was resolved or mitigated.

   Information on all previous OSHA-reportable mishaps (OHS Forms 200 & 300) that have occurred in the past 3 years to include: any fatalities that have occurred; identify whether the investigation has been completed and the results; The cause of the safety and health mishaps; describe the

corrective action taken and when it was implemented. If the corrective action has not yet been implemented, provide the planned implementation date. The following website shall be used to verify data. (http://www.osha.gov/oshstats/index.html)

4. Subcontractors performing asbestos related work at NASA JSC must provide their firm's Safety and Health Plan in accordance with paragraph 1 above. This plan must discuss work procedures, provide a written Hazard Communication Program, and provide a written Respiratory Protection Program. This plan must demonstrate compliance with 29 CFR 1926.1101, 29 CFR 1910.134, and JPR 1700.1 Part 12 Asbestos Control Requirements. The Contracting Officer will approve this written document before the subcontractor is allowed to perform asbestos work at JSC.

5. Subcontractors who require the use of respiratory protection, or voluntarily allow it to be worn, must provide a written Respiratory Protection Program demonstrating compliance with 29 CFR 1910.134. The Contracting Officer will approve this written document before the subcontractor is allowed to perform work at JSC.

6. Subcontractors performing work with lead-containing materials at NASA JSC must provide a written plan demonstrating their compliance with 29 CFR 1926.62. The Contracting Officer will approve this written document before the subcontractor is allowed to perform work at JSC.

7. Subcontractors performing leading edge work; or working on scaffolds, roofs, steel structures; or working at unprotected heights above 6 feet must provide must provide a written fall protection plan demonstrating compliance with 29 CFR 1926 Subparts L, M, R, and X as applicable.

8. Subcontractors performing work on energized systems (electrical, hydraulic, kinetic, mechanical, pressurized, etc) must provide a written plan demonstrating compliance with isolation and lockout/tagout (LOTO) requirements of 29 CFR 1910.147 and JPR 1700.1 Chapter 3.5 "Hazard Correction Tracking".

1.6.4 Changes to Safety and Health Plans

After acceptance of the Safety and Health Plans, the Contractor shall notify the Contracting Officer in writing a minimum of seven (7) calendar days prior to any proposed change. Proposed changes must be submitted to the Contracting Officer for approval.

1.7 SAFETY AND HEALTH SYSTEM ORGANIZATION REQUIREMENTS

1.7.1 Safety & Health System Specialist (SHSS)

The Contractor shall provide a Safety & Health staff at the work site at all times during progress with complete authority to take any action necessary to ensure compliance with the Safety & Health Contract requirements. All Safety & Health personnel shall be subject to acceptance by the Contracting Officer. The following are considered minimum requirements and should be supplemented as necessary to assure adequate staff to meet the Safety & Health requirements at all times during construction.

The Contractor shall identify an individual, within his organization work site, who shall be responsible for the overall Safety & Health System and have the authority to act in all Safety & Health matters for the Contractor. The SHSS shall report directly to the site management authority or upper management in the Contractor's off-site organization. This SHSS shall be on-site at all times during construction, unless: An alternate for the Safety & Health System Specialist is identified in the plan to serve in the event of the Safety & Health System Specialist absence. The SHSS will not be absent from the work site for periods exceeding 1 week at any time, and not more than 20 workdays during a calendar year. The requirements for the alternate shall be the same as for the designated Safety & Health System Specialist.

The Safety & Health System Specialist shall either: (i) have a Bachelor of Science or higher degree in Engineering, Safety, Industrial Hygiene, or related field from an accredited institution, with a minimum of 5 year's Safety & Health experience on similar type construction, or (ii) be a Certified Safety Professional (CSP) as defined by the Board of Certified Safety Professionals (BCSP). http://www.bcsp.org/

1.7.2 Safety & Health System Staff

The Contractor shall provide as part of the Safety & Health System organization, as a minimum, specialized personnel for each definable feature of work (see Section 01 45 04.00 80 CONTRACTOR QUALITY CONTROL). These personnel shall assist and report to the SHSS. Each person will be responsible for assuring the Safety & Health complies with the Safety & Health requirements for their area of specialization. These individuals shall be responsible to the SHSS; be physically present at the construction site during work on their areas of responsibility; have the necessary education and experience in Safety & Health System compliance in those areas. A staff shall be maintained under the direction of the SHSS to perform all Safety & Health activities. The staff must be of sufficient number to ensure adequate Safety & Health System coverage for all features of work, crafts, work shifts, and work crews involved in the construction. These personnel may perform other duties, but must be fully qualified by experience and technical training to perform their assigned Safety & Health responsibilities and must be allowed sufficient time to carry out these responsibilities. The Safety & Health Plan will clearly state the duties and responsibilities of each staff member.

1.8 Special Safety and Health Program Requirements

1.8.1 Hazard Assessment and Daily Safety and Health Review

Identify hazardous operations as defined in JPR 1700.1 Chapter 10.1 "Safety And Health Requirements For Facilities And Facility Systems" and Chapter 5.8 "Hazardous Operations: Safe Practices And Certification".

Identify safety and health hazards associated with construction activities

Prior to the start of work, prepare and submit Hazard Assessments (i.e. Job Hazard Analysis (JHA), Job Safety Analysis (JSA), Work Site Hazard Analysis (WSHA)), which includes hazard abatement procedures and controls, for each definable feature of work or identified hazardous operation in accordance with JPR 1700.1, Chapter 3.5 "Hazard Correction Tracking".

This Hazard Assessment shall be documented on the Hazard Assessment Worksheet form (attached to this section) or equivalent. The hazard

assessment will list tasks/steps, describe potential hazards, specify required engineering, administrative, or personal protective equipment (PPE) controls, and verification. The foreman or crew chief will be familiar with the hazard assessments applicable to his/her activities.

The Contractor and each Subcontractor shall conduct Daily Safety and Health Review meetings with his/her employees before the start of each crew's work shift activities or before the start of a new task/activity during a work shift. See paragraph titled "Meetings" above. The daily review will address all hazards listed on the Hazard Assessment Worksheet.

The hazard assessments shall be updated as conditions change

1.8.2 Pre-use Planning for Hazardous Operations

The Contractor shall submit the following information relating to hazardous operations and the equipment used in those operations requiring a pre-use inspection.

Pre-use plans, drawings, or sketches for crane lifting/rigging, working under suspended loads, scaffold erection, fall protection, excavations and trenching, blocking, and demolition.

Advanced notification of equipment to be used on-site, which requires pre-use inspections, must be made at least 48 hours prior to intended use. Advance notification is required for scaffolding, lifting, blocking, fall protection, and mechanized equipment.

The Contractor shall complete Johnson Space Center Forms JF8, Hazardous Operation Permit, or JF 1475, Hot Work - Welding - Cutting Permit, for operations as described in JPR 1700.1, Chapter 3.5 "Hazard Correction Tracking". These permits are required for activities involving welding, torch cutting, operating a crane, applying pesticides, working with high voltage electricity, operating aerial lift buckets or truck platforms, operating Class 3A or 3B or 4 lasers, using radioactive materials, using industrial x-ray machine, and handling cryogenic materials. These forms shall be provided to the appropriate JSC office for approval and issue of permit prior to the start of the operation.

1.8.3 Critical Lifts

Critical lifts are identified as those lifts that involve special, high dollar items, one-of-a kind articles, spacecraft or major facility components, whose loss would have serious programmatic or institutional impact. Critical lifts must follow the requirements for "critical lifts" in NASA Technical Standard; NASA-STD-8719.9; NASA Standard for Lifting Devices and Equipment; Revised 9 May 2002. Critical loft requirements include: special design features, maintenance, inspection, and test intervals, extra operator training and certification, and specific written procedures for each lift.

1.8.4 Emergency Response

The emergency telephone numbers for use at JSC will be posted in a readily visible location.

The contractor shall exercise his emergency procedures for fire, personnel injury, and property damage within the first 60 calendar days of the notice to proceed and at least annually there after.

All fires and all accidents requiring medical response will be reported immediately by telephone to the JSC Emergency Operations Center (EOC) at 281-483-3333 (or 281-244-4444 at Ellington Field)

1.8.5 Minimum Construction Safety Training

JSC 0.5-hour Orientation to Safety and Health at Johnson Space Center for all employees prior to issuance of site access badge.

Houston Area Safety Council (HASC) 4.5-hour General Safety, Health, and Hazard Recognition - "Basic Orientation Plus" for all employees prior to issuance of site access badge. Valid for 2 years.

HASC 1.5 hours JSC Site Specific Safety and Health Awareness for all employees prior to issuance of site access badge. Valid for 2 years.

OSHA 10-hour 29 CFR 1926 Construction Industry Safety Training (craft specific) for all first line supervisors (i.e. foremen, crew chiefs) and employees designated as a "competent person." Valid for 4 years.

OSHA 30-hour 29 CFR 1926 Construction Industry Safety Training for all project managers, superintendents, supervisors and the SHSS. Valid for 4 years.

JSC 3 hour Confined Space Training for employees prior to entering a Confined Space and first line supervisor, project managers, superintendents, competent person, and the SHSS. Valid for 2 years.

JSC 4 hour LO/TO Training for exposed employees, first line supervisor, project managers, superintendents, competent person, and the SHSS. Valid for 2 years.

JSC 6 hour Asbestos Class III O&M (Restricted) if do Class III asbestos work. Initial plus annual 2 hour refresher.

OSHA Asbestos training as required by JPR 1700.1, Part 12 if do Class I/II/III work. Initial plus annual refresher.

The Contractor shall conduct Safety and Health orientation training with all employees of each crew prior to the start of each definable feature of work. The orientation will discuss The Safety and Health Program, hazard analyses, procedures, the Hazard Communication Program, emergencies, training, and permits. Attendance will be recorded. The Contracting Officer shall be notified at least 48 hours in advance of this training.

1.8.6 Approved Training Sources

JSC offers onsite S&H training on a pre-established schedule basis that will be made available. Courses listed above may also be obtained from the Houston Area Safety Council (HASC) or other Safety Council that is listed as a member in good standing with the "Association of Reciprocal Safety Councils, Inc.(ARSCI)"

1.8.7 Proof of Training

Employees shall maintain evidence that the required training has been completed and is current prior to working on the jobsite. Acceptable evidence of training:

Badge from HASC or ARSCI.

Card(s) issued by JSC.

OSHA Card showing course topic signed by an OSHA certified trainer.

Attendance records for safety and health orientation training.

1.8.8 Training Documentation

The Contractor shall submit documents showing that employees performing any OSHA Class I/Class II/Class III asbestos work at JSC have received the training required by JPR 1700.1, Part 12, Asbestos Control Requirements. A copy of a current Texas Department of Health (TDH) Asbestos Worker License or a current TDH Asbestos Supervisor License is sufficient documentation of training for OSHA Class I and Class II work. These documents shall be submitted to the Contracting Officer for review prior to start of any asbestos related work.

The Contractor shall submit documents showing that employees performing any OSHA Class I/Class II/Class III asbestos work at JSC have a current medical examination and a current respirator fit test.

The Contractor shall submit documents showing that employees performing Lead Abatement Work are trained to the requirements of OSHA Standard 29 CFR 1926.62 and have a current respirator fit test. A copy of a current TDH Lead Abatement Worker License is sufficient documentation of training. These documents shall be submitted to the Contracting Officer for review prior to start of any lead abatement work.

Documentation of Asbestos Training, Lead Abatement Training, and all other required Safety and Health Training shall be maintained on-site by Contractor and shall be made available for review by the Contracting Officer.

1.8.9 Hazard Communication Program

The Contractor shall have a written Hazard Communication Program meeting the requirements of OSHA Standard 29 CFR 1910.1200.

Provide a listing of all hazardous material to be used on the contract and a Material Safety Data Sheet (MSDS) for each item on the list. Current lists and MSDS shall be provided prior to each Construction Feature of Work.

The Contractor shall submit MSDSs using a NASA/Johnson Space Center Form, JF 277, Request for Material Safety Data Sheets Processing, for inclusion in the JSC MSDS Database as required by JPR 1700.1, Chapter 3.5 "Hazard Correction Tracking". The MSDSs must be accepted before the hazardous material is brought on-site.

The Contractor shall maintain at the contract job site a copy of the hazardous material list(s) and an MSDS for each hazardous material used during the life of the contract.

The Contractor shall ensure that each subcontractor is covered by a Hazard Communication Program

1.8.10 Exposure Monitoring

The Contractor shall conduct any personnel exposure monitoring required for work involving airborne inhalation exposures to hazardous materials.

Contractor shall submit copies of exposure monitoring results, along with an explanation of the operation monitored, to the Contracting Officer.

The Government's Safety and Health representatives may conduct personnel or environmental exposure monitoring to verify the adequacy of work procedures. Exposure monitoring may be conducted for exposures to asbestos, lead, and other hazardous chemicals. The Government will furnish the contractor the personnel exposure monitoring results. The Government's air monitoring is for the governments use only and is not intended to replace the use of proper safety and health procedures when working with hazardous materials.

1.8.11 Asbestos

1.8.11.1 Existing Asbestos Materials

Existing Asbestos Materials may be found in and on, but not limited to, areas above suspended ceilings, mechanical rooms, and below raised computer flooring. Asbestos containing materials (ACM) are known to exist in spray-applied insulation and fireproofing, sprayed or troweled acoustical ceilings, pipe and boiler insulation, ceiling tiles, and floor tiles. Asbestos dust and debris (contamination) have been found to exist in facilities where there is no visible deterioration of known ACM products. See Section 01 22 00.00 80 SPECIAL REQUIREMENTS to determine if asbestos is expected to be found and/or removed as part of this project. Specific requirements for the handling of asbestos are also addressed in Section 01 22 00.00 80 SPECIAL REQUIREMENTS.

1.8.11.2 New Asbestos Materials

Asbestos materials and products containing asbestos in any form shall not be used, specified, or installed without the express, advanced written consent or direction of the Contracting Officer. In the event of any inconsistency between this specification and any other contract specification, this specification shall apply.

1.8.11.3 Asbestos Related Work

Contractors performing any work involving asbestos must follow the criteria in the JSC Safety and Health Handbook, JPR 1700.1 (latest version), Part 12, Asbestos Control Requirements.

1.8.12 Lead Containing Materials

Lead containing materials may be found at Johnson Space Center on structures, metal siding and decking, door frames, hand rails, and other building system components. Additionally, lead sheeting may be found in roof drains. See Section 01 22 00.00 80 SPECIAL REQUIREMENTS to determine if leaded paint or other lead containing materials are expected to be found and/or removed as part of this project. Specific requirements for the handling of lead are also addressed in Section 01 22 00.00 80 SPECIAL REQUIREMENTS.

Contractors performing any work involving the abatement of leaded paints

and other lead containing materials shall follow the criteria in the OSHA Standard 29 CFR 1926.62. Activities which sand, grind, drill, or burn lead containing paints may cause exposures which exceed OSHA criteria.

Where possible "peel-away" chemical strippers should be used to remove lead containing paints from metal structures, siding, decking, and other metal building components before sanding, grinding, drilling, cutting, welding or torching. The paint shall be removed for a distance of at least six (6) inches on either side of the cut line or area to be worked. If welding or torching, paint shall be removed on all sides of the component.

1.8.13 Noise

The Contractor shall ensure that employees using or working around equipment that produces continuous noise greater than 80 decibels on the A-weighted scale (dBA) wear hearing protection regardless of the duration of exposure.

The Contractor shall ensure that employees using or working around equipment that produces impact/impulse noise greater than 100 decibels peak sound pressure (dBP) wear hearing protection.

The Contractor shall identify hazardous noise areas where hearing protection is required to be worn.

The Contractor shall ensure that employees are instructed on the proper method for inserting ear plugs and wearing aural "ear muff" protectors.

The Contractor shall provide hearing protection to any visitor entering a hazardous noise area.

1.8.14 Confined Spaces

Contractor will complete a Johnson Space Center Form JF992, Confined Space Entry Procedure, for each confined space. The Contractor will provide the JF992 for approval before any entry/entries are made to any designated JSC-Permit or OSHA Permit space. Requirements for confined space entry at JSC are found in JPR 1700.1, Chapter 3.5 "Hazard Correction Tracking".

The Contractor will complete a Johnson Space Center Form JF1476, Confined Space Entry Permit, upon each entry into a confined space and retain completed JFs 1476 on site for review and inspection by the Contracting Officer.

1.8.15 Radiation and Laser Safety

Radiographs shall be performed in an approved manner and in presence of an approved source handler. Prior to bringing any radiograph equipment on the JSC Site, the Contractor shall obtain written approval from the Contracting Officer of the procedure and type and size of radioactive source to be used, plus date and time of testing. No testing shall be performed without a JSC Form 8, Hazardous Operations Permit and presence of the inspector. Approval to perform radiography at other than normal working hours will be granted only when such work introduces hazards to other personnel working in the vicinity of the testing

Any Contractor who brings radioactive material, radiographic equipment, or an x-ray generator onto Johnson Space Center shall submit a copy of their State Agreement License or US Nuclear Regulatory Commission Licenses (See

reference standard 10 CFR 20) to the Contracting Officer prior to the material or device arrival on JSC property.

The use of Class 2, 3 and 4 lasers must be approved by the Contracting Officer before the device is brought onto JSC property. A Hazardous Operations Permit, JSC Form 8, will be submitted for the use of Class 3 and 4 lasers.

1.8.16 Respiratory Protection

Employees wearing tight-fitting face-piece respirators, whether required or voluntary, must show proof of current medical clearance, fit testing, and training.

Contractors and subcontractors allowing employees to voluntarily use filtering face pieces (i.e., dust masks), must provide those employees with training in accordance with 29 CFR 1910.134.

1.8.17 Lockout/Tagout (LO/TO) and Energy Control

The Contractor shall follow the requirements of JPR 1700.1, Chapter 3.5 "Hazard Correction Tracking" for the control of energy (e.g.; electrical, air, steam, or fluid driven mechanisms).

JSC will provide the Contractor with locks to perform lock out for energy control. The Contractor will use the JSC Forms JF 19A and JF 1291A for tag out.

1.8.18 Welding, Burning or Torch Cutting Work

The Contractor must ensure that safety precautions are in effect before, and maintained during the performance of all such work. Personnel and property must be protected from flash burns and sparks. The Contractor shall see that each employee performing such work is thoroughly familiar with all safety requirements.

The operation of all welding, burning, and torch cutting equipment will be checked and approved by a competent person. Any defective equipment shall be put in safe operating condition immediately or removed from the site.

Tarpaulins used for covers or shields must be fire resistant.

Shields must be used wherever possible. Where shields cannot be used, the area must be specifically approved by the Contracting Officer.

An approved fire extinguisher, with the Contractor's name or label on it, is a must requirement with each welding, burning or torch cutting operation. Operation is defined as one or more outfits operating in the same confined area.

The Contractor will complete and provide a JSC Form 1475, Hot Work - Welding - Cutting Permit, to the appropriate JSC office for approval and issue of permit prior to the start of any welding, burning or torch cutting operation.

1.8.19 Open Flames

The use of open-flame heating devices will not be allowed except by special

permission of the Contracting Officer. Such permission will not be granted unless the Contractor has taken all reasonable precautions to make such devices safe to include proper venting. Burning trash, brush, or trees on the job site will not be allowed. Approval for the use of open fires and open-flame heating devices will in no way relieve the Contractor from the responsibility of any damage incurred because of fires.

1.8.20 Flammable Materials

Flammable liquids shall be stored and handled in accordance with NFPA 30, Flammable and Combustible Liquids Code of the National Fire Protection Association.

1.8.21 Fire Extinguishers

The Contractor shall provide a sufficient number of fire extinguishers on site to meet the requirements of 29 CFR 1926.150.

Each fire extinguisher shall be marked or tagged with the Contractor's name. Each extinguisher shall be inspected at least once per month. The inspection will be documented and defective equipment will be replaced immediately.

1.8.22 Severe Storm Warnings

The Contractor shall not perform outdoor construction activities when lightning is within 6 miles of the Center and shall comply with JPR 1700.1, Chapter 5.9 "Weather Safety Requirements".

1.8.23 Drug Free Workplace Program

The contractor must provide a Drug Free Workplace Program that:

1. Contains a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the workplace and specifying the actions that will be taken against employees for violations of such prohibition;

2. Establishes an ongoing drug-free awareness program to inform employees about:

   The dangers of drug abuse in the workplace,

   The policy of maintaining a drug-free workplace,

   Any available drug counseling, rehabilitation, and employee assistance programs,

   The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace.

3. Provides all employees engaged in performance of the contract with a copy of the above statement.

4. Notifies employees in writing in the statement required above that, as a condition of continued employment on this contract, the employee will:

Abide by the terms of the statement

Notify the employer in writing of the employee's conviction under a criminal drug statute for a violation occurring in the workplace no later than 5 calendar days after such conviction

5. Notifies the Contracting Officer in writing within 10 calendar days after receiving this notice of conviction, from an employee or otherwise receiving actual notice of such conviction. The notice shall include the position title of the employee.

6. Within 30 calendar days after receiving notice of a conviction, take one of the following actions with respect to any employee who is convicted of a drug abuse violation occurring in the workplace:

   Taking appropriate personnel action against such employee, up to and including termination; or

   Require such employee to satisfactorily participate in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency; and

7. Make a good faith effort to maintain a drug-free workplace through implementation of paragraphs 1) through 6).

8. A "Controlled substance" means a controlled substance in schedules I through V of section 202 of the Controlled Substances Act (21 U.S.C. 812) and as further defined in regulation at 21 CFR 1308.11 - 1308.15.

1.8.24 Roofing

Flamed Asphalt re-heaters shall not be allowed on building roofs.

1.8.25 Fall Protection

The Contractor shall ensure that any employee working at heights greater than six (6) feet above a lower level (ten (10) feet on scaffold), to include work on a ladder, is protected by a fall protection or fall prevention system.

Employees performing leading edge work shall be protected by a fall protection or fall prevention system.

The Contractor shall protect workers and visitors from falling objects.

1.8.26 Smoking

Work sites shall have designated smoking areas that are away from hazardous operations, and condition risk such as: combustible, flammable, and ignitable sources. Contractor and subcontractor employees shall only smoke in designated areas. Each smoking area shall be clearly marked "Smoking Area", maintained, and enforced by the prime contractor. Each smoking area

shall have an approved method for collection and disposing of smoking products waste.

PART 2 PRODUCTS

Not Used

PART 3 PARTS

Not Used

-- End of Section --

DAILY SAFETY & HEALTH REVIEW

COMPANY (Print Name) _____ **DATE** _____

SUPERVISOR (Print Name) _____ **CRAFT** _____

SUPERVISOR SIGNATURE _____ **LOCATION OF WORK** _____

TASK ACTIVITY – List Basic Job Steps: _____

_____

_____

_____

_____

POTENTIAL HAZARDS:							
A	Electrocution/Shock	**H**	Hot Surfaces	**O**	Excavations/Trenches	**V**	Chemicals (MSDS Review)
B	Fall From Heights	**I**	Pinch Points	**P**	Lead Paint	**W**	Restricted Access/Confined Space
C	Work Overhead	**J**	Flying Particles	**Q**	Silica Dust	**X**	Poor Lighting
D	Lifting: Manual/Mechanical	**K**	Vehicle Traffic	**R**	Asbestos	**Y**	Heat Stress/Cold Temperatures
E	Rough/Sharp Material	**L**	Severe Weather	**S**	Poor Work Position	**Z**	Compressed Air
F	Slippery/Uneven Surfaces	**M**	Welding Fume	**T**	Noise	**AA**	Repetitive Motion
G	Machinery – Rotate/Moving	**N**	Welding Arc	**U**	Flammable Materials	**BB**	Other:

ENTER LETTER OF POTENTIAL HAZARD AND CORRECTIVE ACTIONS FOR EACH JOB STEP:

LETTER:	CORRECTIVE ACTIONS TAKEN TO ENSURE SAFETY: (USE REVERSE OF THIS SHEET IF ADDITIONAL SPACE IS NECESSARY)

SAFETY CHECK LIST

	Y	N		Y	N		Y	N
FIRE PROTECTION PRECAUTIONS			**PPE NEEDED**			**ENERGIZED EQUIPMENT SECURED**		
Fire Blankets			Face Shield			Ground Fault Protection (GFCI)		
Welding Screens			Goggles (Chemical or Particulate)			Lock Out/Tag Out		
Flammables Removed			Hearing Protection			External Barrier		
Fire Extinguishers Available			Gloves-Specific Chemical Hazard			Blank/Blind		
LEL Measured			Gloves-leather			Electrical Tool/Cords Inspected		
Trained Firewatcher Stationed			Rubber Boots			High Voltage Lines Identified		
			Chemical Suits			Hot Pipes Need Temp. Insulation		
PERMITS REQUIRED			Coveralls/Disposable Clothing			Cords/Leads/Hoses Protected		
Hot Work –Welding/Cutting/Torch			Fall Protection Equipment			Utility Procedure Approved		
HazOp – Electrical High Voltage			Respiratory Protection					
HazOp – Crane/Critical Lift Plan			Foot/Metatarsal Guards			**WORK PLATFORMS FOR TASK**		
HazOp – Aerial lift/truck platform			Safety Shower			Scaffold Needed/Inspected		
HazOp – Class 3A/3B/4 lasers			Eye Wash			JLG/Scissors Lift (Oper. Cert.)		
HazOp – Radioactive Materials/X-ray			Flash Resistant Clothing			Ladders (Inspected & Secured)		
HazOp – Cryogenic						Other		
HazOp – Pesticide Application								
Tunnel – Cable Installation/Removal			**BARRICADES NEEDED**			**ABATEMENTS NECESSARY**		
Confined Space Procedure & Permit			Caution (Yellow)			Asbestos		
Electrical Area Work			Danger (Red)			Lead Paint		
Electrical "Hot" work			Hard Barricade			**Other (List)** _____		
Excavation/Digging/Boring			Flashing Lights					
Utility Outage Request			Flag Man/Spotter			**EMERGENCY PROCEDURES**		

CREW SIGN-IN BEFORE TASK		**CREW SIGN-OUT AFTER TASK**
Task Start Time: _____		**Task End Time:** _____
I understand the safety precautions and have the training to perform this task incident free.		I have worked safely today and have not been injured.

(USE REVERSE OF THIS SHEET IF ADDITIONAL SPACE IS NECESSARY FOR SIGNATURES)

POST TASK FOLLOW-UP	Locks Removed		Any Injuries Reported		Roadways, Area Cleared		Area Clean/Secure	

DAILY SAFETY & HEALTH REVIEW

ENTER LETTER OF POTENTIAL HAZARD AND CORRECTIVE ACTIONS FOR EACH JOB STEP:	
LETTER:	CORRECTIVE ACTIONS TAKEN TO ENSURE SAFETY

CREW SIGN-IN BEFORE TASK		CREW SIGN-OUT AFTER TASK
Task Start Time:_____ I understand the safety precautions and have the training to perform this task incident free.		**Task End Time:** _____ I have worked safely today and have not been injured.

Hazard Assessment Worksheet

Company (print name): _____ **Date:** _____

Preparer (print name): _____ **Preparer's Signature:** _____

Definable Feature of Work: _____ **Worksheet Number:** _____

Task or Step	Hazard Description	Required Controls: Engineering, Administrative, PPE	Validation/Verification Methods
1.	a. b. c. …	a. b. c. …	a. b. c. …
2.	a. b. c. …	a. b. c. …	a. b. c. …
3.	a. b. c. …	a. b. c. …	a. b. c. …
4.	a. b. c. …	a. b. c. …	a. b. c. …
5.	a. b. c. …	a. b. c. …	a. b. c. …
…			

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 64 00.00 10

LIQUID CHILLERS

-- End of Section Table of Contents --

SECTION 23 64 00.00 10

LIQUID CHILLERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 550/590	(2003) Standard for Water-Chilling Packages Using the Vapor Compression Cycle

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2007; Errata 2007) Safety Code for Refrigeration

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2001	(2004d) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
AGMA 6011	(2003i) Specifications for High Speed Helical Gear Units

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2007; Errata 2007) Safety Code for Refrigeration

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX	(2007) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2007) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM B 117	(2007) Standing Practice for Operating Salt Spray (Fog) Apparatus
ASTM D 520	(2000; R 2005) Zinc Dust Pigment
ASTM E 84	(2007) Standard Test Method for Surface

	Burning Characteristics of Building Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.110	(1998; R 2004) Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents
IEEE C57.16	(1996) Standard Requirements, Terminology, and Test Code for Dry-Type Air-Core Series-Connected Reactors
IEEE C57.12.01	(2005) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE Std 18	(2002) Standard for Shunt Power Capacitors
IEEE Std 1036	Guide for Application of Shunt Power Capacitors
IEEE Std 112	(2004) Standard Test Procedure for Polyphase Induction Motors and Generators

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2006; Errata 2007) Standard for Motors and Generators
NEMA MG 2	(2001; Rev 1 2007) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements, as specified.

SD-03 Product Data

Refrigeration System; G

Manufacturer's standard catalog data, at least 5 weeks prior to

the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Liquid Chiller

b. Chiller Components

c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Spare Parts; G

Spare parts data for each different item of equipment specified.

Verification of Dimensions; G

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, confirmation of existing conditions, and any discrepancies found.

Coil Corrosion Protection; G

Product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement.

Field Tests; G

Schedules, at least 2 weeks prior to the field test, which identify the date, time, and location for each test. Schedules shall be submitted for the Chiller Performance Test.

System Performance Tests; G

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

SD-06 Test Reports

Field Tests; G

Six copies of the report shall be provided in bound 8-1/2 by 11 inch booklets. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months

prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted 1 week after completion of the factory test.

System Performance Tests; G

Six copies of the report shall be provided in bound 8-1/2 by 11 inch booklets.

SD-07 Certificates

Refrigeration System; G

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, 1 copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organization; G

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT REQUIREMENTS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The mechanical Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. The mechanical Contractor shall submit detailed drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Bolt setting by mechanical contractor.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

1.5.3 Spare Parts

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 1 month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having

less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization, as specified in the Submittals paragraph. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, liquid coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 00 10.00 80 ELECTRICAL WORK. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 FIELD ERECTED INDUSTRIAL LIQUID CHILLER

The chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit shall be rigged and assembled by Manufacturer. Assembly shall include refrigerant reclaim unit and interconnecting refrigerant piping, rigged and setting of VFD and control wiring, rigging and setting of control panel. Manufacturers scope of work shall not include structural, electrical, bolt setting, and mechanical work external to the chiller. Chiller shall operate within capacity range and speed recommended by the manufacturer. Heavy components which must be removed for inspection, cleaning, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the

manufacturer for safe, controlled, automatic operation of the equipment. Chiller's condenser and liquid cooler shall be provided with hinged marine water boxes with welded connections.

2.4.1 Industrial Centrifugal Chiller With Induction Motor Drive

Furnish and install where indicated on the plans one open-drive centrifugal liquid chilling unit(s) as manufactured by York International (Model Titan OM) or equal. Unit(s) to utilize refrigerant R-134a and to be equipped and rated in accordance with ARI 550/590 (latest revision).

Reference chiller schedule on the contract documents for chiller performance requirements.

Electric power shall be supplied to the centrifugal compressor drive motor at 4160 volts/3-phase/60 Hertz for VFD starting (inrush not to exceed full load amps). Motor speed shall be 1800 RPM. Motor to develop 95% full load power factor (minimum).

Main motor starter shall be VFD in a free-standing, floor-mounted NEMA (12) enclosure.

Electric power shall be supplied to all auxiliary motors at 460 volts/3 phase/60 Hz, controls at 120 volts/1 phase/60 Hz; and control air at 80 to 100 PSIG.

The evaporator tubes shall be 20 BWG (0.035 inches nominal wall thickness) copper. The maximum water velocity in the tubes shall not exceed 12 ft/sec. Selection shall be based on 0.00010 ft 2 -°F-hr/BTU fouling factor. Water side shall be 150 PSIG Design Working Pressure.

The refrigerant condenser tubes shall be 20 BWG (0.035 inches nominal wall thickness) copper. The maximum water velocity in the tubes shall not exceed 12 ft/sec. Selection shall be based on 0.00025 ft 2 -°F-hr/BTU fouling factor. Water side shall be 150 PSIG Design Working Pressure.

Oil coolers (compressor and speed increaser) shall be furnished with chilled water at (86)°F maximum temperature and 150 PSIG Design Working Pressure based on 0.0005 ft2 -°F-hr/BTU fouling factor.

Refrigerant transfer unit water cooled condenser shall be furnished with city water at 86 °F maximum temperature and 150 PSIG design working pressure, based on 0.0005) ft 2 -°F-hr/BTU fouling factor. Refrigerant high pressure receiver shall be sized for the full refrigerant charge of 1 unit chiller.

All temperature and pressure displays are to be in English units of measure.

2.5 CHILLER COMPONENTS

Unit shall be specially equipped as required to produce full rated capacity at full flow entering condenser water temperatures down to 55°F (12.8°C), without the use of condenser water flow control or bypass, or cooling tower fan cycling; so as to provide maximum unit operating economies.

Each unit shall consist of a steel driveline base assembly that includes the compressor, speed increaser gear (if required), and motor factory mounted and rough aligned on a steel driveline base; liquid cooler; refrigerant condenser with liquid sub-cooler; intercooler (if required);

refrigerant transfer unit and receiver; necessary interconnecting refrigerant pipe, valves and fittings; level adjusting spring isolators for complete unit; and floor mounted, Programmable Logic Controller (PLC) based, control center with full multicolor graphic display and membrane keypad, for use with an electric induction motor driven chilling system, all suitable for NEMA-1 application. All major components (compressor, cooler, condenser, intercooler and pumpout receiver) shall be factory leak tested, evacuated and protectively charged with nitrogen before shipment. It shall be the responsibility of the installing contractor to furnish all of the necessary labor and material to complete the installation in accordance with instructions and drawings furnished by the manufacturer.

Compressor motor starter shall be furnished for separate field mounting.

2.5.1 Drive Line Base/Assembly

The drive line components noted above are specified in detail below, and shall be supplied factory mounted and rough aligned on a single, rigid fabricated structural steel base, with optical leveling points, to be furnished by the chiller unit manufacturer for controlled alignment. The base shall include provision for level-adjusting, limited rise, spring-type isolators as hereinafter specified; and necessary factory assembled galvanized steel auxiliary cooling water piping and manual valves within confines of base connecting all drive line components to a common manifold, including water solenoid valve and strainer. Individual compressor and gear auxiliary oil pump motor starters with fused disconnect switches shall be furnished for field mounting and wiring on or near the driveline base.

2.5.2 Compressor

Compressor shall be of the open drive, multistage centrifugal type. The casing shall be of industrial construction, horizontally split to allow access to the rotor assembly. Casing design shall be such that major wearing parts (main bearings, thrust bearings, seals, and shaft oil pump) are accessible for inspection or replacement without removing upper half of the casing or disturbing compressor drive alignment. Casing shall have necessary suction, discharge and interstage flash gas connections.

Compressor impeller shaft shall be designed with sufficient rigidity to prevent vibration at any required operating speed and this operating speed shall be below the first lateral critical speed. The shaft shall be manufactured of heat treated alloy steel. Impellers shall be statically and dynamically balanced and made of material which will resist erosion, corrosion and pitting; and preserve initial impeller balance and performance characteristics. Multistage compressor shall include a balance piston on the last stage impeller to minimize axial thrust load on the thrust bearing.

Compressor shall include accessible precision bored aluminum alloy journal bearings, and a tilting pad type thrust bearing to axially position the rotor and absorb any unbalanced thrust which may be encountered.

Compressor lubrication system shall be of the self-contained force feed type with a pump supplying oil under pressure to journal bearings and thrust bearing, and shall include dual replaceable element 15 micron oil filters with change-over valve, a water cooled oil cooler, and a self-contained thermostatically controlled cooler oil bypass valve to maintain desired minimum oil temperature.

Complete lubrication system shall be factory packaged. Compressor shall include a main oil pump, and an auxiliary pump, including provisions to ensure positive lubrication at all operating speeds, on start-up or shut-down, and under power failure coast-down conditions. The oil reservoir shall include heaters to minimize accumulation of refrigerant in the oil during long idle periods. Sight ports, thermometers and pressure gauges shall be supplied. Provide 3-lead, 100 ohm platinum Resistance Temperature Detectors (RTD), and junction boxes with 4-20mA transmitters.

An automatic capacity reduction control of the pre-rotation vane type shall be provided to efficiently regulate the capacity by varying the volume of refrigeration suction gas handled by the compressor, together with a suitable pneumatic operator to automatically position the pre-rotation vanes in response to a temperature control system sensing the leaving chilled water temperature. An automatic hot gas bypass with pneumatic operator shall also be furnished to assure stable performance, even under extreme or abnormal operating conditions, down to 10% capacity.

A non-contacting proximity vibration monitoring system shall be provided as detailed below following Control Center.

2.5.3 Couplings/Coupling Guards

A light-weight, non-lubricated type of high speed coupling and guard shall be furnished between the compressor and the speed increaser gear, or motor. Coupling and guard shall be accessible and easily disassembled without disturbing the compressor drive alignment.

A limited end-float, lubricated, gear type low speed coupling and guard shall be furnished between speed increaser gear, and motor.

2.5.4 Speed Increaser Gear

External speed increaser shall be sized with a 1.3 (min.) gear service factor applied to the maximum continuous power output of the motor. (Motor nameplate HP x Motor SF (1.15) x Gear SF (1.3) = 1.5).

High speed increasers shall be totally enclosed, double helical and be manufactured in accordance with AGMA 6011 standard for application of 1800 rpm motors or 5,000 feet per minute (1524 meters per minute) pitch line velocity.

Housing shall be ruggedly designed to insure maximum rigidity, made of high tensile alloy cast iron or fabricated steel, stress relieved and machined to match the precision of the gears. Housing to have machined leveling pads, vertical jacking screws, inspection cover and oversize drain port. All housing interior surfaces to be thoroughly cleaned, shot blasted and painted prior to assembly.

Gears shall be double helical design, heat treated by through hardening or case carburizing. Gears shall be precision hobbed and shaved, or have end relief and tip relief to eliminate edge loading. AGMA minimum quality level 10 shall be checked and qualified with certification available upon request. Gears shall be designed for life expectancy of 100,000 hours based on Figure 20 and 21 in AGMA 2001. A pressure angle of 20° is required to reduce scoring and sound.

Journal bearings shall be tapered land, split-sleeve, babbitt lined, steel backed, with thrust collars for axial loads. Bearings to be selected to

meet specific speed and design load characteristics. (NOTE: Thrust loads on the highspeed shaft are normally handled by the compressor thrust bearing.)

The lubrication system shall consist of a positive displacement shaft driven pump, auxiliary oil pump, water-cooled oil cooler with a self-contained thermostatically controlled cooler oil by-pass valve to maintain desired minimum oil temperatures, dual replaceable element 25-micron (max.) oil filters with change-over valve, supply oil pressure gauge, oil temperature gauge and wet oil sump. Piping to be external of housing for ease of maintenance. Oil temperature 3-lead, 100 ohm platinum RTD/transmitter, and pressure transmitters, shall be furnished as detailed by the Control Center Input/Output List. Transmitters shall be 4-20mA output. Seals are to be labyrinth type on both high speed and low speed shaft extensions and split horizontally for ease of maintenance. Gear lubrication system shall supply oil to the motor as required.

A non-contacting proximity vibration monitoring system shall be provided as detailed below following Control Center.

Speed increaser gears as manufactured by Lufkin or Nuttall.

2.5.5 Compressor Motor

The prime mover shall be a squirrel cage induction motor sized to efficiently and continuously fulfill the chiller unit compressor brake horsepower (including speed increaser, if required) and speed requirements without exceeding the motor nameplate HP rating, and the motor shall be specifically capable of continuous operation at 115% (minimum) of the total chiller unit power requirements.

All equipment provided shall be manufactured in accordance with the applicable requirements established by the following codes or standards (latest revision), unless otherwise specified: "NEMA Publication No. MG-1, "Motors and Generators" ANSI C50.2, as a supplementary standard for motors. IEEE Publications temperature limits on insulating materials, rating methods, testing (IEEE Std 112), etc." All material and equipment furnished shall be new free from defects of any character.

Motor shall be a horizontal, continuous duty, squirrel cage induction machine. Rating shall be for voltage and speed as previously specified and carry a 1.15 service factor rating. Direction of rotation shall be as required by driven load and shall be prominently indicated on motor on both front and shaft sides, be permanently affixed to each end of enclosure. Motor shall be connected to driven load by means of flexible coupling specified and provided elsewhere in these specifications.

Motor enclosure shall match existing.

Motor shall be premium efficiency type, of size and characteristics required to start the compressor, and bring it up to speed within the specified limitations; and operate the compressor at full load conditions without exceeding motor nameplate horsepower (kW). The starting characteristics of the motor shall be as required for successful full or reduced voltage start-up of the entire unit as previously specified. Manufacturer shall guarantee inrush amperes to be not more than those specified, with the system starting voltage dip previously specified.

Motor and VFD shall be designed and fabricated to develop a minimum power

factor of 0.98. If power factor correction capacitors (PFCC) are required, they are to sized by the motor manufacturer, to be furnished by the starter manufacturer and installed in the starter enclosure.

2.5.5.1 Insulation Characteristics

Winding insulation shall be IEEE Class "F", rated for a maximum "hottest-spot" temperature of 130°C. Motor rating shall permit continuous operation at full nameplate horsepower load with temperature not exceeding 120°C (80°C rise above 40°C ambient) at 1.0 service factor as measured by the resistance method. Stator coils shall be form wound and sealed.

The motor insulation system must incorporate a solvent-less "Vacuum Pressure Impregnated Epoxy", (VPI) process. The insulation must be impregnated after the coils are wound into the stator and connections are made.

Coil end turns shall be securely anchored to lock up the coils, prior to impregnation.

Winding Temperature Sensors: Provide six, 3-lead, 100-ohm platinum RTDs imbedded in the stator coils, two per phase, at 60 degree intervals for connection to the microprocessor-based motor protective unit to be provided in the motor starter cubicle. Provide separate terminal box on motor and terminate all sensor leads therein with ring-tongue terminals under screws.

2.5.5.2 Bearings, Lubrication & Temperature Indication

a. Bearings: Bearings shall be split sleeve, spherically (center) seated, self-aligning design. One bearing must be electrically insulated to prevent shaft electric currents. Design of bearings, housings, and brackets must permit inspection and replacement of bearings without disassembly of motor. The motor shall have horizontally split end bells.

b. Lubrication: Motor to have oil rings and oil level indication on both bearings, if required. If required due to the size and/or speed of the motor, provide flooded lubrication of bearings with necessary seals, piping, orifices, visual flow indication, etc., utilizing the speed increaser positive displacement lube system.

c. Temperature Indication: Provide each bearing with 3-lead, 100-ohm platinum RTDs, and junction boxes with 420mA transmitters for connection to remote temperature readouts on chiller control center.

A non-contacting proximity vibration monitoring system shall be provided as detailed below following Control Center.

2.5.5.3 Rotor

Rotor bars must be fabricated copper, or copper alloy bars; high frequency induction-brazed to centrifugally cast copper, or copper alloy resistance rings. Uniform cross section rotor bars to be swaged to assure tight bar construction and elimination of bar vibration. The use of aluminum in rotor construction will not be acceptable.

Rotor to stator air gap measurements shall be made at final assembly at both ends of the motor. Readings shall be taken at 45° intervals clockwise and each reading recorded, so as to indicate the relative position of the stator, rotor as measurement location. "Twelve O'Clock" shaft position

shall be permanently marked. Readings shall be included in Owner's manuals.

The rotor shall be dynamically and statically balanced. Assembled motor shall be tested at the factory in accordance with latest applicable NEMA MG 1.20.53 method of testing, and balanced to no more than 1.0 mils total peak-to-peak deflection on the bearing housing and 2.0 mils on the shaft Overall vibration readings, including all vibration frequencies, shall be taken and recorded with the motor running at design speed. Readings shall be included in Owner's manual.

2.5.5.4 Space Heaters

Electric resistance space heaters shall be provided inside the motor enclosure. Capacity shall be as required to avoid moisture condensation during shutdown. Heaters shall be automatically energized by the motor starter whenever motor is shut down. Heaters shall be suitable for operation at 120 volts/1-phase/60 Hertz. Provide separate terminal box on motor with all leads terminated with ring-tongue terminals under screws.

2.5.5.5 Surge Protection

Provide arrestors and capacitors for motor voltage surge protection. Surge arrestors shall be station valve type rated 5.0 kV Min. Three-phase surge capacitors shall be rated 0.5 microfarads per phase. Units shall be adequately mounted and braced as indicated on the drawings.

2.5.5.6 Terminal Boxes

Manufacturer shall provide conduit boxes or terminal cabinets for all wiring connections to the motor. Boxes shall be cast iron, cast bronze, or sheet steel with a minimum thickness of 1/8 inch (11 gauge)(3 mm). Cover shall be bolted-on. All joints between box and cover or box and machine frame shall be sealed by means of durable gaskets resistant to heat, oil and moisture laden air. Auxiliary leads such as those provided for bearing temperature sensors, winding etc., shall be terminated on molded insulation terminal blocks in "independent" enclosed terminal boxes or compartments, effectively isolated from the line voltage main terminals.

Each terminal shall be plainly and permanently identified. Boxes shall be mounted for conduit entrance from (below) (above). All bolts and nuts shall be of hexagonal type. Stainless steel hardware is preferred, although other corrosion-resistant metal or finishes are acceptable. All fittings and threaded parts shall be protected during shipment and erection by means of moisture resistant grease or other effective means. Motor main lead terminal box shall include ample space for "stress cone" installation, and OPTIONAL current transformers and/or OPTIONAL surge protection. Submit shop drawings for the surge protection equipment specified above.

2.5.5.7 Nameplates

Motor nameplates shall be stainless steel. Letters shall be permanently stamped and not less than 1/8 inch (3 mm) high. Information to be inscribed on main nameplate shall be per NEMA MG1-20.60, with the addition of the locked rotor current at rated voltage and frequency as determined by actual test. Provide nameplates for: space heaters (voltage and wattage; number of starts per hour; bearing identification and recommended lubricant; direction of rotation; electric-phase rotation for proper direction of mechanical rotation; and motor wiring diagram).

2.5.6 COMPRESSOR MOTOR CONTROLLER (VFD)

The centrifugal chiller manufacturer shall provide a VFD for safe, dependable starting and efficient operation of each compressor motor. Installation and wiring shall be by the manufacturer.

2.5.6.1 Performance

Operating Envelope

VFD shall meet the following speed and torque requirements:

The VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 30-100% speed range. The VFD must be capable of sustained operation at 1/10 speed to facilitate checkout and maintenance of the driven equipment. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without a motor connected to the VFD output.

VFD shall be capable of operating any standard AC motor of equivalent rating (horsepower and speed) over the specified speed range.

Unless specified otherwise on the data sheet, for constant torque loads (extruders, mixers, reciprocating compressors & pumps, conveyors, etc.), the VFD shall be capable of a momentary overload of 150% of rated motor current for one minute out of any ten minutes.

The VFD shall be able to produce full rated torque at any speed in the operating range (constant torque capability).

If high breakaway/starting torque is required, the VFD shall provide full rated torque at standstill and be capable of sustaining that level of torque indefinitely.

Input Harmonics

VFD's shall comply with the latest edition of IEEE 519 for total harmonic voltage and current distortion calculation and measurement and meet the following distortion limits:

Voltage Harmonics: Individual or simultaneous operation of the VFD's shall not add more than 3% total harmonic voltage distortion while operating from the utility source, or more than 5% while operating from standby generator (if applicable)

Current Harmonics: Maximum allowable total harmonic current distortion limits for each VFD shall not exceed 5% as calculated and measured at the point of common coupling.

The VFD converter section shall be eighteen (18) or more pulse (or equivalent harmonic performance without filters) to eliminate the need for harmonic filters. Harmonic filters are undesirable due to the necessity to modify the filters to avoid resonance problems and correct tuning whenever other inductive/capacitive loads are placed on the system or when the power system changes.

Compliance shall be verified by the VFD manufacturer with field measurements of harmonic distortion differences at point of common

coupling with and without VFD's operating. The point of common coupling (PCC) for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the primary connection of each VFD input transformer.

Power quality metering shall be installed in the VFD system to continuously monitor and display input and output power quality. This will allow easy customer verification of power quality and efficiency for the VFD system. The power quality data shall include the following:

Input voltage (average rms value)
Input current (individual phase rms values and average rms value)
Input frequency
Power factor
Input kW, kVAr
Input kWHr
Input current THD (average of three phases)
Calculation of total input current or voltage harmonic demand distortion
Drive efficiency
Motor voltage (rms)
Motor current (rms)
Motor speed (in RPM or %)
Motor flux (%)
Motor torque (%)
Drive output power (kW)
Output kWHr

Motor Compatibility

VFD system shall provide an output waveform that will allow utilization of standard motors, without need of any special insulation or derating. Motor life expectancy should not be compromised in any way by operation with the VFD system. The system must comply with all elements of the Output Harmonics section of this specification. The VFD must provide motor overload protection in any operating condition.

VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor. To ensure that there are no problems with motor heating, VFD output current waveform, as measured at the motor, shall be inherently sinusoidal at all speeds, with a total harmonic current distortion not exceeding 3% referenced to the full load output current fundamental between 10% and 100% speed. VFD's utilizing output transformers are not acceptable.

The system design shall not have any inherent output harmonic resonance in the operating speed range.

The VFD output shall produce no electrically induced pulsating torque to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations. VFD systems, or other types, which produce torque pulsations in excess of 1%, will require a torsional analysis to be supplied by the VFD manufacturer as part of the scope of supply. The price of the torsional analysis shall be included in the base price of the VFD.

VFD shall inherently protect motor from high-voltage v/ t stress, independent of cable length to motor. VFD shall not require nonstandard insulation systems or insulation ratings above the VFD output voltage rating. The VFD system shall be designed to produce no standing waves or over-voltage conditions based on a cable length of at least 2000 ft (~600 m). This is a typical length which will cover most application requirements and allow for potential future cable run changes from VFD to motor. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system and included within the VFD enclosure.

An input transformer shall be included to provide common mode voltage protection and allow the use of a standard motor. Special high-voltage motor insulation is not an acceptable method for protection against common mode voltages.

VFD System Efficiency

Guaranteed minimum total VFD system efficiency (sys) shall be a minimum 96% at 100% load and minimum 95% at 50% load. Efficiency evaluation shall include input transformer, harmonic filter and power factor correction (if applicable), VFD converter, and output filter, as indicated below. Auxiliary controls, such as internal VFD control boards, cooling fans or pumps, shall be included in all loss calculations.

The VFD system efficiency is as follows: sys = VFD x xfmr x pfc x harm x filter

Converter/Inverter (VFD)	VFD	
Input Transformer	xfmr	(Total VFD System Efficiency (sys))
Power Factor Correction	pfc	must be 96.0% at full load
Input Harmonic Filter	harm	and 95% at 50% load.
Output Filter	filt	

Note: If the motor power factor is poor (less than 0.85 at rated load), causing the VFD to provide higher than normal reactive current to the machine, the required total VFD system efficiency requirement will be reduced by 0.5%.

A factory test shall be performed at the VFD manufacturer's facility certifying that efficiencies have been met. A penalty (in dollars per kW) will be assessed if efficiency is not achieved and will be deducted from the contracted price.

System Input Power Factor

VFD system shall maintain a 95% minimum true power factor from 30% to 100% of rated speed. VFD system including power factor correction and/or harmonic filter shall never have a leading power factor under utility or generator operation. VFD manufacturer is to supply a power factor correction system, if required, to meet this requirement. Power factor correction unit shall include a separate input isolating contactor with fuses, power factor correction grade capacitors (voltage class shall be consistent with the VFD system input voltage), and series harmonic de-coupling reactors, all integrated into VFD system and mounted within the VFD enclosure. A penalty of $1,000.00 per kVA (or other value as specified on the data sheet) will be assessed if power factor is not achieved and will be deducted from the

contracted price.

Speed Regulation

VFD speed regulation shall be ±0.5% without encoder or tachometer feedback.

Sound Level

Maximum allowable audible noise from the VFD system will be 75 dB(A) at a distance of one meter (3.3 ft) at any speed or load condition. VFD systems with audible noise in excess of this limit must be provided with sufficient noise abatement treatment to reduce the sound pressure level below 75 dB(A).

2.5.6.2 Availability

Firing Signals

All internal firing signals, and other communications(which link operational controls with power components such as status and diagnostic signals) must meet noise immunity and safety requirements as defined by applicable EN Norms and IEEE Standards.

Power Interrupt Ride-Through

The VFD system must be capable of continuous operation in the event of a power loss of 5 cycles or less.

The VFD system must be capable of automatically restarting in the event of a momentary loss of power. The VFD system shall provide the user with the choice of automatically restarting or not. The user shall be able to selectively apply this feature and have the ability to set the allowable restart time applicable to some (but not necessarily all) conditions as determined by the user to be appropriate for the specific application.

Power Sag Ride-Through

The VFD system shall be capable of continuous operation with a thirty (30) percent voltage sag on the input power line.

"Catch-A-Spinning-Load" Capability

The VFD system must be able to catch and take control of a spinning load if started while rotating equipment is already spinning. Appropriate safeguards must be included in this operation to prevent damaging torque(s), voltages or currents from impacting any of the equipment. The user shall have the option of employing this feature or disabling it.

Auto-Restart Capability

The VFD system must be capable of automatically restarting in the event of a process or drive trip. The VFD system shall provide the user with the choice of automatically restarting or not. The user shall be able to selectively apply this feature to some (but not necessarily all) conditions as determined by the user to be appropriate for the specific application.

Ground Fault Withstand

In the event of a ground fault, the VFD shall capable of annunciating the ground fault condition, safely operating and, by user selection, either trip or continue operation. As a result of a ground fault trip, the VFD shall be capable of being reset and operating normally. There shall be no risk of fire or electric shock as a result of the ground fault.

2.5.6.3 SERVICEABILITY/MAINTAINABILITY

Front Access

VFD system should be designed for front access only. Manufacturer shall state in his proposal if rear or side access is required. An explanation of reason for any required rear or side access shall be given.

Power Component Accessibility

All power components in the converter sections shall be designed for rack-out accessibility for ease of maintenance and to minimize repair downtime. Alternate access options must be described in the proposal for purchaser's review and evaluation.

Voltage Isolation

All low voltage components, circuits and wiring shall be separated with physical barriers from any sources of medium voltage.

Remote Diagnostics

The VFD system shall be provided with the capability for remote diagnostics via ether-net link.

Marking/Labeling

Sleeve type wire marker tags or other acceptable means of permanent identification shall be applied to power and control wiring. Individual labels shall be provided for all major components of the VFD system.

Mean Time TO Repair (MTTR)

The VFD design must demonstrate an actual mean time to repair of less than 15 minutes, in the event of any power switching component failure.

2.5.6.4 Physical Requirements

Environmental Requirements

VFD system shall be capable of continuous operation in an average ambient temperature between 0°C and 40°C at an elevation up to 3300 feet (1000 meters) above MSL without derating. The VFD system shall also be simultaneously suitable for continuous operation in a maximum humidity between 0 and 95% non-condensing.

Heat Dissipation/Cooling System-

VFD system shall be air-cooled unless air-cooling is unavailable or impractical, in which case liquid-cooling shall be provided.

Air-Cooling Requirements

Air-cooled VFDs shall be provided with fan redundancy and automatic switchover in the event of a fan failure for enhanced reliability. If a fan fails, the system must automatically switch to the alternate fan and generate an alarm to notify operator of initial fan system failure. Drive must have ability to detect failed operation of the cooling system (using temperature detectors as the only protection against loss of fan system is not acceptable). During normal operation, the system must periodically cycle between the two fan systems to "exercise" them and prevent drying out of bearings, seals, etc., and to ensure availability of all systems. VFD system manufacturer shall provide heat dissipation data necessary to design all auxiliary HVAC systems.

Enclosure

All VFD system components including transformer shall be mounted and wired by the VFD system manufacturer in a grounded enclosure meeting the following requirements without exception:

Input filters, transformer, power conversion, output filters and auxiliary equipment enclosure sections shall be NEMA-12 design. Air-cooled units shall be NEMA 12 Ventilated, IP-41 or better degree of protection, with gasketed doors. Liquid-cooled units shall be NEMA 12 Non-Ventilated, IP-52 or better degree of protection. All agency listed VFDs shall be Class I enclosures, NEMA 12 like construction. Air-cooled units shall have clean-able filter media covering all air inlets. Inlet air filters shall be 100% washable, with a progressively structured, corrosion-free media. Filters shall be front replaceable (for cleaning) while the VFD is in operation without exposing maintenance personnel to any of the power components. Cabinet color shall be ANSI 61 Gray. Paint procedures and materials shall be manufacturer's system designed and proven for resistance to chemical attack in industrial power-house environments.

Microprocessor and control logic boards and their power supplies shall be housed in a sealed, non-ventilated NEMA-12 section, safely accessible without exposure to high voltages and without drive shutdown. All low voltage wiring shall be fully isolated from medium voltage compartments by metal barriers.

Cabinets and doors shall be fabricated using heavy gauge steel (12-gauge minimum) for sturdy construction and dimensional integrity to assure long-term fit and function. All doors shall be gasketed to provide environmental protection and secure fits.

Enclosures must be designed to avoid harmonic and inductive heating effects. When specified, the enclosure must be designed to shield any outside equipment from interference, enclosing and shielding the complete to eliminate any radio frequency interference. VFD system shall be labeled with CE Mark.

Installation/Cabling

Owner will provide labor to set equipment in place. All VFD system wiring (power, control & protection) shall be located internally within the VFD system enclosure. All external power conductors (bus or cable) shall be insulated. Power wiring shall be isolated by voltage class. Control and protection wiring shall be isolated from power wiring.

Space Limitations - Footprint

The VFD system must fit in the space indicated on project drawings.

Interlocks

Mechanical key interlocks shall be provided on all doors. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including transformer, filters or any switchgear that is part of the supply, when line power is applied to the VFD system. Interlocks must be mechanical to provide positive lock-out prevention and safety. Electrical interlock switches alone are not acceptable, due to the possibility of inadvertent shutdown and the ease with which such switches could be bypassed.

Control Power

To power the VFD cooling system and VFD control circuits low voltage, 3-phase low-voltage auxiliary power will be provided by the Customer. The VFD supplier shall provide a low voltage circuit breaker to allow foe the isolation of this power supply source. This auxiliary power voltage shall be 3 phase with voltage determined by customer. For Air-cooled VFDs only, an auxiliary power transformer shall be supplied to convert input medium voltage power to low voltage to provide power for control logic and auxiliary cooling motors. A separate low-voltage circuit breaker shall be provided to allow for the control power feed from a customer supplied low voltage supply source. All VFD control circuits shall be 120 VAC single phase. Manufacturer shall provide an internal control power transformer suitably rated to provide all VFD required control power.

2.5.6.5 Protective Devices/Diagnostics

Power Component Protection

VFD system shall include distribution class surge arrestors to protect input transformer and VFD against voltage surges.

The VFD system shall include power fuses on the input to the converter rectifier devices to protect the secondary of the transformer from any potentially harmful fault currents. While alternative arrangements that involve coordinated protection with an input circuit breaker are not as desirable, if proposed, the VFD system provider must include all coordinating elements including the circuit breaker itself and must provide a detailed description of the protection scheme with the proposal.

Protective Features and Circuits

The controller shall include the following alarms and protective features:

Static instantaneous over-current and over-voltage trip.

Under-voltage and power loss protection.

Over-temperature protection.

Electronic motor inverse time overload protection.

Responsive action to motor winding temperature detectors or thermostatic switches. A dry contact (NC) input to the VFD is required.

When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed without the use of an encoder.

The VFD system shall be protected from damage due to the following, without requiring an output contactor:

Single-phase fault or three-phase short circuit on VFD system output terminals.

Failure to commutate inverter thyristor due to severe overload or other conditions.

Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.

Loss of one (1) phase of input power.

Motor regeneration due to backspin or loss of VFD input power.

The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:

Failure to connect a motor to the VFD output.

VFD output open circuit that may occur during operation.

The VFD shall include a customer selectable automatic restart feature. When enabled, the VFD shall automatically attempt to restart after a trip condition resulting from over-current, over-voltage, under-voltage, or over-temperature.

Data Displays

A door-mounted LCD display shall be furnished, capable of displaying the VFD operational status and drive parameters. The digital display must present all diagnostic message and parameter values in plain language (English or otherwise, as noted on the data sheet) engineering units when accessed, without the use of codes.

As a minimum, the following door mounted digital indications shall be supplied:

Speed demand in percent
Input current in amperes
Output current in amperes

Output Frequency in hertz
Input voltage
Output voltage
Total 3-phase KW output
Kilowatt hour meter
Elapsed time running meter

Diagnostics & Fault Recording

The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors.

Fault log data storage memory shall be stored in non-volatile memory or be supported by a UPS sized to provide a minimum of 48 hour data retention.

The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

A "FAULT LOG" shall record, store, display and print upon demand, the following for the 50 most recent events:

VFD mode (Auto/Manual)
Date and time of day
Type of fault
Reset mode (Auto/Manual)

A "HISTORIC LOG" shall record, store, display and print upon demand, the following control variables at an adjustable time interval for the 50 intervals immediately preceding a fault trip and 100 intervals following such trip:

VFD mode (manual/auto/inhibited/tripped/etc.)
Speed demand
VFD output frequency
Demand (output) Amps
Feedback (motor) Amps
VFD output volts
Type of fault:
Drive inhibit (On/Off)
The fault log record shall be accessible via a RS232 serial link as well as line by line on the keypad display.

A "Windows-based" graphical tool suite shall be available with the VFD. This graphical PC tool shall be able to plot and display up to 8 different VFD parameters and have the ability to freeze plotting and print hard-copy versions of the plots. Capability to display at least 8 different VFD system parameters is required and all parameters displayed on the PC tool shall be synchronized with the standard keypad display.

2.5.6.6 Programming & Communications

User Input/Keypad

The door of each power unit shall include manual speed device, a mode selector marked "Manual / Automatic", a "POWER ON" light, a VFD "FAULT" light, a VFD "RUNNING" light, start pushbutton, stop

pushbutton and reset pushbutton.

A door-mounted keypad with integral digital LCD display shall be furnished, capable of controlling the VFD and setting drive parameters. The display must present all diagnostic message and parameter values in standard engineering units when accessed, without the use of codes. The keypad shall allow the operator to enter exact numerical settings in standard engineering units. A plain language (English or other language, as noted on the data sheet) user menu (rather than codes) shall be provided in software as a guide to parameter setting.

Drive parameters shall be factory set in non-volatile EEPROM registers and re-settable in the field through the keypad. A minimum of six (6) levels of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred for programming of new or spare boards.

The keypad module shall contain a "self-test" software program that can be activated to verify proper keypad operations.

The VFD system shall have the user selectable option of programming up to three speed avoidance bands. This gives the user the ability to block out and prevent operation at any undesirable speed, such as one that may be coincident with a mechanical resonance condition.

Hard-wire Communication

Additional analog input and output signals and additional digital inputs and outputs shall be provided.

Serial Communication/Protocols/Modem or Cable

VFD shall be capable of direct communication to an IBM or compatible computer for serial link setup of parameters, fault diagnostics, trending and diagnostic log downloading. An RS-232 port shall be door-mounted for computer or printer interface. VFD parameters, fault log and diagnostic log shall be downloadable for hard copy printout via the RS-232 or Ethernet port and a standard serial printer.

The VFD shall be provided with single port digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system. The communication protocol shall be determined by the customer.

An Ethernet communications link shall be provided.

The new Chiller PLC shall communicate with the existing Building 28 PLC's via the existing Allan Bradley Data Highway Plus and shall contain an Ethernet Card to communicate with the existing Honeywell Ebi via the existing JSC LAN.

2.5.6.7 Component Requirements

Printed Circuit Boards

All printed circuit boards shall be new. They shall be conformally coated for moisture and chemical resistance, in addition to any

dielectric coating properties. All boards must be tested in accordance with paragraph entitled, Subassembly Tests.

Power Bus and Wiring

Main power bus shall be high-conductivity and plated for chemical and corrosion resistance and low losses. Bus shall be appropriately sized for the VFD continuous current rating and braced to withstand the mechanical forces caused by a momentary short circuit current of 40 kA expected at the bus. All connections shall be bolted or continuously welded. Main grounding of the VFD system shall have a common loop consisting of copper cable placed in the enclosure base. This cable will ground the base and will be attached to stainless steel grounding pads welded to the base on two locations, one at each end of the enclosure.

All control wiring shall be physically separated from the power wiring. Low and high voltage cables shall be physically isolated from each other. The VFD system shall be pre-wired within the enclosure. Spade type connectors are not acceptable. No soldering shall be used in connection with any wiring. Wiring shall be adequately supported to avoid tension on conductors and terminations. All wiring shall be run in surface mounted conduit or wire-ways. Any section of wiring outside of conduit or wire-way shall be securely tied with cable ties at intervals not exceeding six inches. No cables shall be tied off to or in any way supported from power busses. Wherever wiring passes metal edges or through holes, suitable guards or grommets shall be provided to prevent cutting or chafing of the insulation.

All wiring shall be tagged with permanent labels at each termination, junction box, and device. Labels shall correspond to the schematic and wiring diagrams.

Ground Connection

Corrosion resistant grounding pads shall be provided in each power cubicle. A copper ground bus shall be provided for grounding of control circuits.

Input Isolation Transformer

The VFD system is to be supplied with a drive isolation transformer to provide common mode voltage protection and phase shifting (for 18 pulse or higher converter bridge, if employed to meet the power quality requirements. VFD systems utilizing input three phase AC line reactors which require motors equipped with special higher voltage rated insulation systems are not acceptable and will not be allowed as an alternate bid.

Transformer design to be a rectifier grade isolation type with a K-Factor of 12 for variable torque loads or a K-Factor of 20 for constant torque loads when applied to a SCR converter, in accordance with current EPRI recommendations and IEEE C57.110. A K-Factor of 6 is required for diode rectifier converters. Transformers shall have a BIL rating in accordance with the requirements of IEEE C57.12.01.

If dry type construction transformers are required, maximum 115°C rise and minimum 220 C insulation with over-temperature protection. Transformers shall be OA rated and applied in a FA installation.

If oil-filled type transformers are required due to size or other project specific need, they shall have a maximum temperature rise of 55°C and insulation rated for 155°C with over-temperature, Buchaltz and sudden pressure protection. If the total oil capacity of the transformer exceeds 500 gallons, the oil sump and containment provisions shall be supplied as part of the VFD system.

If direct liquid-cooled transformers are required due to size or other project specific need, they shall be dry-type, epoxy cast construction, with a maximum temperature rise of 30°C and insulation rated for 220°C and over-temperature protection.

DC Link Inductors

DC link inductors if required shall be air core to prevent saturation. Separate inductors (split dual winding type) shall be provided in the positive and negative leg of the DC link to minimize stray magnetic fields. Maximum temperature rise shall not exceed 115 C with minimum 220 C insulation and over-temperature protection. To minimize cabling costs the inductors shall be integral to the VFD system lineup. If it is not possible to integrate the inductors into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system supplier, and approved by the Customer's Engineer. Inductors shall meet the requirements of ANSI C57.16 and shall be designed to prevent saturation under maximum fault current conditions.

DC Link Capacitors

Capacitors used in the converter DC link shall be integral to the VFD system lineup to minimize cabling costs.

Capacitors used in the converter DC link shall contain discharge resistors and capable of reducing the residual charge to 50 volts or less within five minutes after the capacitor is disconnected from the source of supply.

Input Harmonic Filters

If after meeting insulation characteristics above, harmonic filters are still required to meet power factor requirements, stricter local requirements, or telephone interference factor restrictions, the VFD manufacturer must provide the filter, upstream filter isolation, protection and protection coordination. As harmonic filters are power system dependent, the VFD supplier is responsible for maintaining and providing any required upgrades required for the first ten years of operation at zero cost to the owner. To minimize cabling costs the harmonic filter components shall be integral to the VFD system lineup, but isolated from other components, such that they can be disconnected from the power source and accessed for maintenance/repair while the VFD is in operation. If it is not possible to integrate the filters into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system supplier, and approved by the Customer's Engineer. Harmonic filters must be located on the primary side of the input isolation transformer and must be switchable with the VFD, to prevent their remaining on the power line in the event of a VFD trip which could create a damaging leading power factor condition. The complete filter must have independent

protection for over-current, phase differential and ground fault.

Any inductors used shall be iron-core or air-core with a maximum temperature rise of 115 C with minimum 220 C insulation and over-temperature protection. Reactors shall be designed to prevent saturation under maximum fault current conditions. Reactors shall meet the requirements of IEEE C57.16.

Capacitors used in the harmonic filter banks shall meet the requirements of IEEE Std 18 and IEEE Std 1036 for shunt power capacitors. Capacitors used in any harmonic filter banks shall be provided with a method of shorting the phases to ground once power has been removed and the capacitors have been discharged to a safe voltage level. Where oil-filled capacitors are required and the total volume of oil exceeds 500 gallons, the oil sump and containment provisions shall be supplied as part of the VFD system.

Output Filters

If an output filter is required to meet the output harmonics requirements of this specification, or to meet any special requirements of the application, they must be fully incorporated into the VFD system design. To minimize cabling costs the output filter components shall be integral to the VFD system lineup. If it is not possible to integrate the output filters into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system supplier, and approved by the Customer's Engineer.

Any inductors used shall be iron-core with a maximum temperature rise of 115 C with minimum 220 C insulation and over-temperature protection. Reactors shall be designed to prevent saturation under maximum fault current conditions. Reactors shall meet the requirements of IEEE C57.16.

Capacitors used in the harmonic filter banks shall meet the requirements of IEEE Std 18 and IEEE Std 1036 for shunt power capacitors.

Where potential exists for self-excitation between the output filter and the motor system, a fully (voltage and current) rated output contactor shall be provided by the VFD supplier as part of the VFD system delivery.

Input Power Terminations

Input and output power connections shall be made to isolated, supported and plated bus strap connections. Sufficient space shall be provided for termination connections from the top or the bottom of the VFD cubicle. Space provisions shall be provided for application of standard stress cones, and provisions shall be provided for grounding of shielded cabling.

2.5.6.8 Switchgear

Switchgear shall be provided for the VFD system in accordance with Medium Voltage VFD Switchgear Specification Guide.

2.5.6.9 Accessories

Additional accessories shall be provided for the VFD system in accordance with VFD Accessories Specification Guide.

2.5.6.10 Control Building/Drive House

If required, a control house shall be provided for the VFD system and any related equipment. The control house shall be in accordance with Electrical Equipment Enclosure Specification Guide.

2.5.6.11 Testing

Subassembly Tests

Printed circuit boards shall be visually inspected and functionally tested. All boards must be tested individually prior to assembly to minimize any impact faulty boards may have on delivery schedules and system reliability. Each board shall be load and temperature cycled from no load to full load and from ambient to +60°C during a 48-hour burn-in test. Any boards that exhibit drift during the test must be replaced with boards that have successfully completed the burn-in without drift.

Power assemblies shall be visually inspected and then HIPOT tested. Complete diagnostics and logic shall be tested. The complete power conversion circuit shall be thoroughly tested at 100% load for a minimum of one hour and then tested for one minute at momentary overload rating, to reduce potential problems in advance of final system testing.

System Level Tests

The system (as defined in Article 1.2 above) shall be given preliminary checks including verification of electrical connections including ground connections, power and control wiring shall be resistance checked point-to-point. E-prom and EE-prom shall be checked for correct revision level. Visual check shall be performed to verify: degree of protection for cabinets, input isolation is lockable in the off-position, marking of terminals and wiring, space availability for cable termination, accessibility of components and ease of maintenance and repair. The VFD system shall be fully checked against the approved drawings for compliance and correct physical dimensions.

Power circuit and all control circuits shall be HIPOT tested to ground.

All control voltage levels are to be checked and verified.

A no load test is to be performed on the system. Drive is to be connected to an unloaded motor and feed back signals shall be verified. Output voltage shall be calibrated. All logic and interlocks including customer logic and instrumentation shall be tested.

Drive shall be given a full power test at rated current and rated voltage (simultaneously) for a minimum of four hours on a dynamometer or reactor load. This test shall be performed as an integrated system including all supplied input switchgear, input transformer, input

filter (if supplied), power section and output filter (if supplied). The VFD manufacturer shall perform the factory system test to verify that total system efficiency, power factor and harmonic distortion limits are met as specified. Total system efficiency shall be measured using watt-meters or Multilin PQM or approved equivalent meters on both the input and the output of the complete system. System shall not be shipped unless specified performance criteria are met. Certified test data of all tests conducted shall be provided with final documentation.

When required, the testing shall be witnessed by customer's representative(s). A projected test schedule and a copy of proposed test procedures shall be provided at least one month in advance of test date. Customer shall be given at least one-week notice or confirmation of actual test date(s).

2.5.6.12 Documentation

With Proposal

Proposal information shall include, but not be limited to:

Preliminary Spare parts list

Certification of Compliance with this Specification

Warranty

Preliminary Dimensions and Weights

VFD System continuous Current and Voltage Rating

VFD System 1 minute Current Rating

Efficiency and Power Factor at 100%, 75%, 50% and 25% load

Input Current at 100%, 75%, 50% and 25% load

Current & Voltage Harmonic Distortion Analyses

External interconnection one-line wiring diagram showing all power, control and protection cabling required to complete the VFD system on-site

After Order Submittals

Submittals shall be custom prepared by the VFD system manufacturer for this specific application.

Submittal information shall include, but not be limited to:

Equipment dimensions, including stub-up locations, shipping splits and shipping weights

Spare parts list

Certifications

Warranty

Efficiency and power factor values

Harmonic distortion analysis

Final

Final documentation shall include the following:

Start-up and commissioning instructions and data

Certified "as-built" drawings of all equipment with information listed above

Operation and maintenance manual

Manufacturer's service and repair support during and after warranty

Spare parts lists with supplier names and part numbers

2.5.6.13 Delivery

VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable. Cabling for connection across shipping splits shall be neatly coiled and identified. Exposed sections of equipment shall be fully protected from damage during shipment. All necessary hardware for reconnecting shipping splits shall be provided.

2.5.6.14 Warranty

All equipment furnished under this section shall be warranted by the contractor and the equipment manufacturer(s) for a minimum period of one (1) year after completion of startup or 18 months after shipment, whichever occurs first. Warranty shall include all parts, labor and expenses to perform necessary work.

2.5.6.15 Start-Up

VFD system manufacturer shall provide the field services of a factory technician as necessary to supervise/inspect installation, test and start-up all equipment provided as part of the fixed price proposal. The firm price shall include all travel and living expenses in addition to the engineer's time required to complete supervision of the installation, testing and start-up. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

Verification of VFD input harmonic voltage and current distortion limits specified must be verified at rated speed and rated power as part of final startup and acceptance. A recording type Fluke, Multilin PQM, BMI or equivalent harmonic analyzer displaying individual and total harmonic currents and voltages must be utilized.

2.5.6.16 SPARE PARTS

The following spare parts shall be furnished:

Three of each type of power and control fuse.

Four of each type of power semiconductor (SCR, SGCT, IGBT, IGCT, power

diode, etc.) used in the converter/rectifier or inverter.

Eight of each type or size of DC link capacitor.

Two of each type or size of input and output filter capacitor.

Five of each type of panel lamp.

One keypad

One fiber optic connector of each type

For liquid cooled VFDs, one spare de-ionizer medium cartridge or media change

For air cooled VFDs, one set of replacement air filters

For air cooled VFDs with belt driven blowers, one set of belts

One of each control printed circuit board, two of each type gate firing boards, include all diagnostic system printed circuit boards.

2.5.7 Pressure Vessels - Asme Code

Pressure vessels (cooler, condenser, intercooler and pumpout receiver) as hereinafter specified shall be designed, constructed, tested and stamped in accordance with the requirements of the ASME Boiler and Pressure Vessels Code, Section VIII, Division 1. Refrigerant Side Design Working Pressure (DWP) shall be as determined by manufacturer for the refrigerant and service; and cooler and condenser water side DWP shall be as previously detailed in this specification.

2.5.8 Cooler And Condenser

The liquid cooler and refrigerant condenser shall be of the horizontal shell and tube type with necessary integral mounting stands including provision for level-adjusting, limited rise, spring-type isolators as hereinafter specified. The shells shall be of steel with fusion welded seams having steel tube sheets welded to each end of shell, and internal intermediate tube support sheets to support tubes at 48-inch (1219 mm) maximum spacing. Shell shall be fabricated so each tube may be individually replaced. Tubes shall be roller expanded into tube sheets to ensure a gas tight joint. Integral marine water boxes, factory welded to the tube sheets, shall be furnished with removable covers to permit access to the tubes for inspections and cleaning without disturbing or breaking any piping connections. Water connections shall be radially oriented, weld end, sealed for shipment.

2.5.9 Cooler

Liquid cooler shall be fabricated as specified above for COOLER AND CONDENSER and shall include liquid headers and a distribution baffle to ensure optimum liquid refrigerant distribution, and a tube bundle configuration to ensure wetting of tubes under all load conditions. Adequate space shall be provided above tube bundle for separation of refrigerant liquid and vapor, and a suction baffle or mesh eliminator shall be furnished located to ensure uniform distribution of suction gas flow and to prevent liquid from being carried over to the compressor. Cooler tubes shall be roller expanded into intermediate tube supports. The cooler shall

be provided with sight ports and a suitable relief device in accordance with ASHRAE 15 (latest edition) Safety Code (and local codes) consisting of bursting disc(s) in series with relief valve(s). Properly sized suction, liquid inlet, hot-gas bypass, liquid transfer and relief connections shall be provided.

2.5.10 Condenser

Condenser shall be fabricated as specified above for COOLER AND CONDENSER and shall include a discharge gas baffle to provide efficient distribution of discharge gas and to prevent direct impingement of gas on tubes, and an integral axial flow liquid sub-cooler, with pilot refrigerant liquid level controller and pneumatically operated high pressure liquid valve. Properly sized discharge gas inlet, liquid outlet, hot-gas bypass, pumpout and purge connections shall be provided.

2.5.11 Intercooler

Each multistage compressor unit shall be furnished with a flash type refrigerant intercooler to improve overall cycle efficiency.

Intercooler shall be of welded steel construction, and shall include necessary low pressure float valve, fully accessible without breaking piping connections, to meter refrigerant liquid flow to the cooler; and interstage gas mist eliminators. Properly sized liquid inlet, liquid outlet and interstage gas connections shall be provided, together with means of external manual operation of float valves. Provision shall be made for level-adjusting, limited rise, springtype isolators as hereinafter specified.

2.5.12 Refrigerant Transfer Unit/Pumpout Receiver

A complete compressor operated transfer unit and horizontal pumpout receiver shall be provided to permit transfer and isolation of the refrigerant charge, as previously specified. The pumpout receiver shall be of welded steel construction and include integral floor mounting stands, dial type liquid level gauge, and dual relief arrangement in accordance with ASHRAE 15 (latest edition) Safety Code (and local codes), consisting of bursting discs in series with relief valves. Properly sized refrigerant liquid, gas and relief connections shall be provided.

The refrigerant transfer unit shall be certified under ARI Standard 740, of the open reciprocating compressor type belt drive with a 10 HP (7.5 kW) open drip proof motor, with water cooled condenser, oil separator and necessary safety controls for manual operation, including starter with fused disconnect switch and control power transformer. The refrigerant transfer unit shall be factory mounted on and piped to the receiver. Piping shall include necessary valve manifolding for efficient refrigerant liquid/gas transfer.

2.5.13 CONTROL CENTER

Each unit shall be furnished with YORK designed and programmed control center based on an Allen-Bradley PLC5/20 (programmable logic controller) or (most current version available) with an A-B PanelView 1000 or (most current version available) 10.4" COLOR ACTIVE MATRIX (TFT) display of all operating and protective parameters, and operator terminal keypad. The controls shall be factory assembled and wired in an upright, finish painted, rugged steel NEMA-1 enclosure with locked full height rear access

door(s).

The control center shall contain all necessary controls and control logic to provide stand-alone automatic start-up, fail-safe fully automatic operation, electronic capacity control and safety protection of the chiller unit, speed increaser gear/electric motor drive. It shall also provide for automatic pre-lube and post-lube operation of the speed increaser gear and compressor auxiliary oil pumps (AOP); and operation of the AOPs during any low pressure lube condition. Controls shall also be included for automatic control of compressor capacity to limit maximum motor power consumption, manually adjustable 100 to 40% of chiller capacity.

Control center shall be 100% electronic/electric, with all values graphically displayed. Refrigerant, oil and bearing temperatures and/or pressures, and control supply air pressure, are all to be electronically monitored from locally mounted RTDs with transmitters and pressure transducers to be furnished as part of the chiller unit. Also to be monitored are pre-rotation vane, high pressure liquid valve, interstage gas valve, and hot gas valve signals; drive motor power requirements; and chilled and condenser water flows and temperatures. This data is to be displayed on a series of color graphic screens, including, but not limited to: Screen List, Compressor Lube System, Main Compressor Status List, Refrigerant/Water System, Manual/Automatic Control, Capacity Controls Tuning, Refrigerant and Water Status Lists, Miscellaneous Operating Status List, and Alarm History.

The control center shall also include an Emergency Stop button, bypassing all controls. It is to be mounted on the front of the control center, together with the color graphic display and its membrane keypad; and the Start, Stop, and Reset buttons.

All controls are to be arranged for easy access - internally wired to clearly marked terminal strips for external (field) wiring connections; wiring color coded black (control), white (neutral), and green (ground), with each wire numerically identified at both ends. A copy of the unit wiring diagram is to be provided in a pocket inside the enclosure door.

The control center is to be supplied a 7.5 kVA 120 volt/1-phase/60 (50) Hertz power supply from the compressor motor starter (OPTIONAL), or from a separate source (by others). The control center is to be all electric. The prerotation vanes, high pressure liquid valve, interstage gas valve, and hot gas valve are all to be electronically controlled and pneumatically actuated, and are to be supplied a total of 4-5 SCFM (1890 to 2360 cc/s) of clean dry filtered instrument air at 80 to 100 PSIG (310 to 390 kPA) pressure (By others).

2.5.13.1 Field Installed Components

Ashcroft Type K1 pressure transmitters shall be provided for points specified on the Input/Output List, for installation near the process connection. Lockable stainless steel ball valves (Appollo 76-103-27) shall be provided for each root connection.

Temperature sensors shall be 3-wire, 100 ohm platinum RTDs with MINCO Model TT676 temperature transmitters having 4-20mA DC output. Ranges shall be selected to cover all expected operating conditions but kept to a minimum to ensure best possible accuracy. Temperature sensors/transmitters shall be provided for the points specified on the Input/Output List.

The hardwired Compressor Oil High Temperature Cutout shall be Ashcroft T420TS. The hardwired Compressor Oil Low Differential Pressure Cutout shall be an Ashcroft D420B. These switches shall be factory installed locally on the compressor.

The hardwired Condenser Refrigerant High Pressure Cutout shall be an Ashcroft B420B and shall be field installed without any intervening stop valve, as required by ASHRAE 15 safety code.

The hardwired Evaporator and Condenser Water Low Differential Pressure Cutouts shall be Ashcroft D420B, and shall be installed locally near the water nozzles.

Brandt Model STD5131-6 electro-pneumatic transducers with 4-20mA input and 3-15 psi output shall be provided for compressor pre-rotation vanes, hot gas valve, interstage valve and subcooler level control valve signals.

2.5.13.2 INPUTS: See Notes 1, 2 and 3

Symbol	Description	Signal Remarks
Analog Inputs		
FT-100	Chilled Water Flow	4-20mA By Others Note 1
FT-102	Condensing Water Flow	4-20mA By Others Note 1
JT-160	Motor Kilowatts	4-20mA Note 2, 3
LT-114	Subcooler Refrig. Liquid Level	4-20mA
PT-111	Evaporator Refrig. Pressure	4-20mA
PT-113	Condenser (Compr. Disch.) Pressure	4-20mA
PT-116	Intercooler Refrig. Pressure	4-20mA
PT-140	Compr. Supply Oil Pressure	4-20mA
PT-143	Compr. Sump Pressure	4-20mA
PT-144	Compr. Shaft Pump Oil Pressure	4-20mA
PT-146	Compr. Balance Piston Pressure	4-20mA
PT-150	Gear Supply Oil Pressure	4-20mA
PT-156	Gear Shaft Pump Oil Pressure	4-20mA
PT-190	Control Supply Air Pressure	4-20mA
TT-100	Chilled Water Out (Supply) Temp.	100 Ohm RTD/4-20mA Transmitter
TT-101	Chilled Water In (Return) Temp.	100 Ohm RTD/4-20mA Transmitter
TT-102	Refrig. Cond. Water In (Supply) Temp.	100 Ohm RTD/4-20mA Transmitter
TT-103	Refrig. Cond. Water Out (Return) Temp.	100 Ohm RTD/4-20mA Transmitter
TT-111	Evaporator Refrig. Liquid Temperature	100 Ohm RTD/4-20mA Transmitter
TT-113	Compressor Refrig. Discharge Temp.	100 Ohm RTD/4-20mA Transmitter
TT-114	Condenser Refrig. Liquid Temp.	100 Ohm RTD/4-20mA Transmitter
TT-115	Subcooled Refrig. Liquid Temp.	100 Ohm RTD/4-20mA Transmitter
TT-142	Compr. Shaft End Bearing Oil Temp.	100 Ohm RTD/4-20mA Transmitter
TT-147	Compressor Thrust Bearing Oil Temp.	100 Ohm RTD/4-20mA Transmitter
TT-150	Gear Supply Oil Temp.	100 Ohm RTD/4-20mA Transmitter
TT-151	Gear Bearing Temp., HS Shaft End	100 Ohm RTD/4-20mA Transmitter
TT-152	Gear Bearing Temp., HS Blind End	100 Ohm RTD/4-20mA Transmitter
TT-153	Gear Bearing Temp., HS Shaft End	100 Ohm RTD/4-20mA Transmitter
TT-154	Gear Bearing Temp., HS Blind End	100 Ohm RTD/4-20mA Transmitter

TT-161	Electric Motor Drive End Bearing Temp.	100 Ohm RTD/4-20mA Transmitter
TT-162	Electric Motor Blind End Bearing Temp.	100 Ohm RTD/4-20mA Transmitter
TE-160A	Electric Motor Stator Temp., Phase A1	100 Ohm RTDNote 3
TE-160B	Electric Motor Stator Temp., Phase A2	100 Ohm RTDNote 3
TE-160C	Electric Motor Stator Temp., Phase B1	100 Ohm RTDNote 3
TE-160D	Electric Motor Stator Temp., Phase B2	100 Ohm RTDNote 3
TE-160E	Electric Motor Stator Temp., Phase C1	100 Ohm RTDNote 3
TE-160F	Electric Motor Stator Temp., Phase C2	100 Ohm RTDNote 3

Digital Inputs

M1A Compr.	Motor Starter "Start" Interlock	120VAC	Note 2
M1B Compr.	Motor Starter "Run" Interlock	120VAC	Note 2
M2 Compr.	AOP Starter Interlock	120VAC	Note 2
M3 Gear	AOP Starter Interlock	120VAC	Note 2
MPD86	Starter Safety Fault Lockout Relay	120VAC	Note 2

PDSLL-101	Chilled Water Press. Differential (Switch)	120VAC
PDSLL-102	Cond. Water Press. Differential (Switch)	120VAC
PDSLL-140A	Comp. Low Oil Press. Switch (Hardwired)	120VAC
PSHH-113A	Cond. Hi Refrig. Press. Switch (Hardwired)	
TS-120	Oil Separator Temperature Switch	120VAC
TSHH-147A	Compr. Oil High Temp. Cutout (Hardwired)	

-	Chiller Start Push-button	120VAC
-	Chiller Stop (Normal) Push-button	120VAC
-	Reset Push-button	120VAC
-	Emergency Stop Push-button	120VAC

2.5.13.3 OUTPUTS

Symbol	Description	Signal
Analog Outputs		
LY-114	Subcooler Level Control Valve	4-20mA
PDY-116	Interstage Control Valve	4-20mA
TY-100A	Compressor Pre-rotation Vanes	4-20mA
TY-100B	Hot Gas Bypass Valve	4-20mA
Digital Outputs		
FCV-105	Aux. Cooling Water Solenoid Valve	120VAC
FCV-114	Liquid Injection Solenoid Valve	120VAC
FCV-120	Gas Supply to Oil Eductor Solenoid	120VAC
R1	Compressor Motor Start Relay	120VAC
R2	Compressor AOP Motor Start Relay	120VAC
R3	Gear AOP Motor Start Relay	120VAC
R4	Chilled Water Pump Emergency	120VAC Note 4

Start Relay

R5	Compressor Oil Heater Control Relay	120VAC
M8	Oil Separator Heater Contactor	120VAC
PCV-143B	Compressor Auto Sump Vent Solenoid	120VAC

NOTES:

Chilled and condenser water flow measurement stations are to be supplied by others. Their design, selection, proper application, and installation should be defined in the appropriate parts of the project specifications. These specifications should address the accuracy needed for use of the data intended (flow tested/calibrated to 1/2% of reading for ARI 550/590 testing, informational, etc.). Also, installation methods must comply with industry and manufacturer's requirements (particularly straight lengths up and downstream, coordinated pipe wall thickness). Please provide YORK with details on flow elements and transmitters.

The specifications of the individual components monitored above (chiller components, speed increaser gear, electric drive motor, motor starter, etc.) shall make provisions for, and the supply of Inputs listed above, such as pressure taps, block valves and 4-20mA transmitters for pressure measurement; thermal wells with 3-wire 100 Ohm Platinum RTDs with 4-20mA Transmitters (except for motor stator) for temperature measurement; AOP starter interlocks; main drive motor starter interlocks, CTs, PTs, kW Transducer; etc.

Monitoring of motor stator temperatures will be most effectively accomplished by the comprehensive and sophisticated monitoring and protection provided by incorporating a microprocessor based motor protective unit (MPU), - such as Cutler-Hammer/Westinghouse IQ1000/ IQ Data Plus II in the motor starter, as previously specified, in which case monitoring of motor stator temperatures would be accomplished by the MPU. Motor bearing temperatures will be monitored in the chiller control panel. In all cases, a separate utility grade kilowatt transducer is required for input to the chiller panel.

This contact output is energized by an evaporator low refrigerant pressure condition. The customer must establish chilled water flow through the chiller when this contact is closed to prevent tube freeze-up. It is recommended that this contact be hardwired into the chilled water pump motor starter control circuit.

2.5.14 VIBRATION MONITORING SYSTEM

Factory-mounting:

Provide Bently-Nevada 3300 or 3300 RAM series proximity probes at those radial and thrust bearings specified in paragraph 2 below.

Extension cables and proximitors to be terminated in proximitor housings supplied and installed by chiller manufacturer, or sub-vendors, and mounted on the machinery skid.

Chiller Driveline Bearings Configurations:

Compressors:

Two proximity probes installed on each of two (2) radial bearings 90 degrees apart in an X-Y configuration.

One proximity probe installed at the thrust bearing in a Z (axial) configuration.

One keyphasor probe for speed reference signal.

Speed Increasers:

Two proximity probes installed on each of two (2) low-speed shaft radial bearings and each of two (2) high-speed shaft radial bearings, 90° apart in an X-Y configuration.

One keyphasor probe on low speed shaft for speed reference signal.

Compressor Motors: Two proximity probes installed on each of two (2) motor shaft radial bearings 90° apart in an X-Y configuration.

Control Center Monitoring Configurations

Chiller control center shall monitor all vibration signals with a Bently Nevada Model 1701 monitoring system, displaying those levels in a vibration monitoring screen on the Allen-Bradley PLC based control center.

2.5.15 Miscellaneous

The unit manufacturer shall also furnish the following for each unit:

Necessary steel refrigerant piping, valves and fittings to interconnect the compressor, condenser, cooler, and intercooler including high pressure liquid and interstage gas valves; automatic hot gas bypass valve, piping and fittings; and necessary refrigerant and oil gauge and control piping. Also necessary steel refrigerant piping, valves and fittings to interconnect the liquid chilling unit and the refrigerant transfer unit/pumpout receiver located within fifty (50) ft (15,240 mm) of each other. All piping shall be furnished in accordance with ANSI B31.5 Piping Code.

Oil return unit (electrically heated), and piping for field mounting, piping, and wiring.

Necessary external lines for compressor lubrication system.

Necessary compressor and gear oil pump starters, and refrigerant transfer unit compressor motor starter, for field mounting and wiring.

5-in. (127 mm) dial bimetal-type thermometers for bearing supply oil, thrust bearing discharge oil, compressor sump oil, compressor refrigerant discharge gas and low pressure refrigerant liquid.

Special wrenches and/or special tools necessary for proper compressor installation and maintenance; and tool box.

Complete initial charge of refrigerant and lubricating oil for compressor and drive line components.

Level-adjusting (jack-screw) spring type vibration isolator

assemblies, limited rise, with non-skid pads - designed for 1-in. (25 mm) deflection - for mounting the compressor drive line assembly, shell assembly and intercooler.

One coat of factory applied heavy duty Ameron Amerloc (dark blue) epoxy primer, suitable for field applied thermal and/or acoustic insulation, and finished coat paint.

2.6 ACCESSORIES

2.6.1 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include three sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be capable with the facility's energy management and control system (EMSS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.6.2 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.7 FINISHES

2.7.1 Factory Coating

2.7.1.1 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Coating shall be applied at either the coil or coating manufacturer's factory. Coating process shall encure complete coil encapsulation. Coating shall be capable of withstanding a minimum 1,000 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution.

2.7.1.2 Equipment and Components

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.7.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the liquid cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.8 FIELD TESTS

2.8.1 Chiller Field Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, in accordance with ARI 550/590 except as indicated. The chiller test shall be performed in the presence of a Government representative. The Contractor and chiller manufacturer shall provide to the Government a certified chiller field test report to confirm that the chiller performs as specified. At a minimum, chiller capacity shall be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation shall be in strict accordance with ARI 550/590. Mechanical contractor shall provide testing and balancing equipment for waterside, and all labor. Manufacturer shall provide supervision of test. All testing procedures and equipment/meters shall be approved by chiller manufacturer.

2.8.1.1 Temperature Adjustments

Temperature adjustments shall adhere to ARI 550/590 to adjust from the

design fouling factor to the clean tube condition. Test temperature adjustments shall be verified prior to testing by the manufacturer. There shall be no exceptions to conducting the test with clean tubes with the temperature adjustments per ARI 550/590. The manufacturer shall clean the tubes, if necessary, prior to testing to obtain a test fouling factor of 0.0000.

2.8.1.2 Test Report

A certified test report of all data shall be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation shall be provided.

2.8.1.3 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer shall be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Government to witness the retest.

2.9 SUPPLEMENTAL COMPONENTS/SERVICES

2.9.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.9.2 Refrigerant Piping

Refrigerant piping for split-system liquid chillers shall be provided and installed in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.9.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00.00 10 COOLING TOWER.

2.9.4 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 23 00 00.00 40 HEATING, VENTILATING AND AIR-CONDITIONING AND 23 09 12 CONTROLS FOR CENTRAL COOLING AND HEATING PLANT and into the existing air-conditioning system.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII Dland ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.1.1 Refrigeration System

3.1.1.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ASHRAE 15. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, liquid coolers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration to match existing at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.1.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system shall be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor shall provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system shall be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points shall be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant shall be pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 3 ounces of refrigerant be released to the atmosphere in any one

3.4 SYSTEM PERFORMANCE TESTS

3.4.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.
(2) Condensing temperature and pressure.
(3) Suction temperature and pressure.
(4) Running current, voltage and proper phase sequence for compressor motor.
(5) The actual on-site setting of all operating and safety controls.
(6) Chilled water pressure, flow and temperature in and out of the chiller.

3.5 SUPERVISION AND INSTRUCTION

The manufacturer shall also include the services of the manufacturer's representative to instruct the owner or his operating personnel in the proper operation and maintenance of the unit for a period of five (5) days for first unit, plus three (3) days for each additional unit.

The contractor shall include in his bid the services of the manufacturer's factory trained field representative to supervise the installation and the assembly of all components to be field assembled at the job site.

-- End of Section --